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# AN INDUSTRIALIZED HOUSING SYSTEM

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## ABSTRACT

The objective of this thesis was to develop a rational and efficient industrialized housing system. We focused on the exploration of the totally factory-built dwelling modules as the most promising strategy for raising productivity to keep pace with the increased housing demand and for lowering construction costs. Our approach was to minimize the work that would have to be done on the site and increase the factory process, thus eliminating inefficient on-site labor.

We recognized transportation regulations and building codes as the major constraints on the design. The presented housing modules are transportable over the highways and meet the requirements of fire-resistive construction type B for residential construction. We limited our investigations into the design of an industrialized housing system to utilize the present technology which is at our disposal. Throughout the project development, the use of standard methods of construction was emphasized to reduce initial investment in the unit fabrication and construction.

This study includes the development of prefabricated housing units from initial conception to final erection procedure. The standard dwelling modules or "boxes" are fabricated with steel as the basic structural framework and gypsum as the enclosing material, and completed on the interior and exterior. The resulting two sizes of standard dwelling modules, 13' 0" x 13' 0" x 9' 6" and 13' 0" x 26' 0" x 9' 6", together with concrete elevator core and staircase units, can be combined and recombined to accommodate various sizes and types of housing for both high and low rise buildings. It was our intention to provide as many variations as possible within the system, to meet the various demands of the housing market. We were aware of the hazards of standardization which we hoped to overcome. A sense of the resulting environment was always kept in mind.

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# 1. INTRODUCTION

## INDUSTRIALIZED SYSTEM AS THE MOST PROMISING TOOL OF HOUSING PRODUCTION TO MEET THE PRESSING NEED

Though industrialization of the housing manufacturing process is high on the agenda of national priorities, there has been no radical change either structurally or technically. Housing production in the United States can hardly be called an industry, although it is a twenty-five billion dollars a year business.[1] The industry's structure and level of technology reflect different institutional constraints and characteristics which are highly fragmented in responsibilities. The housing industry is lagging behind. This lag in housing production, in addition to the growing need for new households and the accompanying deterioration of about one quarter of existing housing units, can be expected to contribute substantial pressure for new housing in the near future. The Kaiser Report has recommended a ten-year goal of twenty-six million more new and rehabilitated housing units, including at least six million for lower-income families.[2]

Now may well be the time for a serious attempt to apply the impressive technology, which is so evident and potent in our society today, to the problems of producing housing more efficiently and more intelligently. We hold the strong conviction that within the next decade the consumer and the housing industry will, in appreciable numbers, come to

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1. See "An Assembly-line Answer to the Housing Crisis," Fortune, May 1, 1969.

2. See the Report of the President's Committee on Urban Housing, A Decent Home, p. 3.

accept the concept of the factory-produced home.

While the "tinkertoy" or component system, which is one of the approaches to the design of industrialized housing, is widely used in the United States, box systems or three-dimensional units are most successfully produced solely in mobile homes. Only recently, the U.S. housing industry, together with a small group of architects, engineers, industrial designers and manufacturers, and encouraged by the success of the mobile home, has begun to explore the potential of dwelling modules or "boxes" suitable for production in factories and capable of being transported over highways, positioned on the site by cranes, and organized in various configurations.[3]

An industrialized or systems approach to building offers the following advantages to the construction of housing:

> Housing can be produced more rapidly than by conventional methods of construction. This increased speed of construction responds to the pressing need for housing, and at the same time results in significant savings because of shorter interim financing, and rents start coming in sooner.
>
> The efficiency of the labor force is increased and relatively unskilled labor can be used, thus reducing some expensive labor input by greater reliance on highly mechanized equipment in factories.
>
> Employment would be continuous and not affected by the weather.

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3. See "Lowering the Cost of Housing," Progressive Architecture, June, 1968.

Bulk purchases of materials, appliances and furnishings, as needed inputs, offer some significant cost savings.

Industrialized processes offer the opportunity for greater quality control, insuring dimensional accuracy, minimum tolerances and better coordination in all its phases - production management, financing, marketing and design.

With these specific advantages of factory production, our conviction in favor of industrialized systems is in the minimization of site work and the increase in the factory process. Housing should be provided by the production of larger, completely industrialized elements installed with a minimum of on-site labor. It is our belief that houses are going to be built in the factory in the same manner as Detroit builds automobiles, with the hope that as a consequence of industrialization, housing production will become plentiful and prices within the reach of low-income families.

## 2. CONCEPTS OF THE DESIGN OF INDUSTRIALIZED HOUSING

Since repetition is the ideal program for mass production, in our approach to the design of an industrialized housing system we particularly emphasize the provision of as many varieties as possible in terms of dwelling units of different sizes and types. We believe that designs must reflect consumer priorities and that a sense of the resulting environment must always be kept in mind throughout the design process. We share Walter Gropius's opinion of industrialized systems in the following quotation:

> "...... For residential buildings, a wrong turn is taken when the manufacturer tries to repeat the same type of house indefinitely. I foresee that we will end up with a great many component parts of houses obeying basic dimensions, which will be used by all manufacturers who compete with each other. This will make it feasible to assemble different looking houses according to the different requirements of families, but made from the same standardized component parts."[4]

In this context, we hope that in the future both the manufacturers and the designers will commit themselves to the principle of interchangeable parts, a commitment that will require very close cooperation between the various manufacturers involved.

Inspired by this generalized concept of achieving variety in design, the presented system emphasizes the use of standard sizes of modules. The study of family needs was made to determine the standard modular

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4. See "U.S. Progress in Preassembly," Progressive Architecture, October, 1964, p. 221.

unit plans. Each modular unit is not an end in itself but a building component capable of being manufactured as a separate unit and combined and recombined with other units. The system provides variation, both in the design of the unit modules and in the combinations of modules that form various apartment building types and single family houses.

It was our intention to arrange the adjacent units both parallel and perpendicular to each other. This potentially adds many alternative configurations and suggests greater adaptability to site conditions as well as varieties of building forms.

# 3. SELECTION OF MATERIALS OF CONSTRUCTION

## 3.1 Structural Material of Modular Units

Steel, associated with industrial production and technology and being readily available, was selected as the basic structural material. With the preconceived idea of designing dwelling units by the combination of modular units, steel could be used as the structural element to fulfil the requirement of apartment planning. However, it should be pointed out that the kind of spans involved in apartment house construction do not exploit the structural economy of the material due to the fact that the apartment house requires small spatial areas. The major advantages of steel in construction lie in its speed and precision of erection with close dimensional tolerances and overall reduction in the weight of the building.

The major problems with steel as a construction material lie not only in the high cost of the material itself, but just as significantly in its inherent problems, e.g., fire protection in multistory buildings, atmospheric protection, expansion-contraction, noise. It can be concluded that steel lacks functional capacity. The most significant property of steel is its strength. Any other functions that have to be performed by a building element must be performed through the addition of other materials. The linear nature of steel combined with its lack of functional versatility leads to the fragmentation of construction in different parts not only of steel but also other materials. In this respect, steel is at a serious disadvantage in relation to concrete, which possesses adequate strength and at the same time is capable of fulfilling a number of other functions.

However, it was our intention to explore the potential of steel as the structural frame of modular units for housing. It should be noted that most recent proposals of this nature are still paper exercises. Therefore, our purpose was to investigate and develop a practical method of design and construction of high-rise and low-rise buildings that would effectively and economically utilize structural steel.

### 3.2 Enclosing Material of Modular Units

We found that utilization of gypsum boards as enclosing material to the structural steel framework offers the best solution to the problems inherent in steel construction, especially in acoustical and fire resistant requirements (itumescent paints, and mineral fiber either sprayed or in sheet form, can also be used for fire-proofing). Other reasons for selecting gypsum as the construction material for floors, partitions and ceilings, are:

1. it is lightweight and dry;
2. it is relatively inexpensive;
3. it is easy to produce with standard construction methods;
4. it is flexible for making different sizes of floors, wall panels or ceilings;
5. it provides an acceptable interior surface.

## 4. DIMENSIONS OF MODULAR UNITS

The two sizes of modular dwelling units in the presented design are 13' 0" x 13' 0" x 9' 6" and 13' 0" x 26' 0" x 9' 6". These sizes of modular unit result from the following criteria:

1. Highway Transport Regulations. Modules are transported on highways from centrally located factories. Many state highway regulations impose limits on the distance a building unit may be moved in relation to its size and weight. In general, a unit not exceeding the dimensions of 13' 0" wide, 10' 0" high and 60' 0" long can be transported without a special permit and police escort. Therefore we adhered to these dimensions as limits for the design of the unit. In the case of a factory being set up on site, these transport regulations would no longer be a restriction on the size of the modular units, and units with larger width could be produced.
2. Weight. It is obvious that the weight of the unit directly affects the cost of shipping and handling and of the supporting structure and foundation. The weight of the modular unit should be minimized. With respect to this criterion we selected steel components and gypsum boards as the materials of construction.
3. Space Requirements. Room sizes within these dimensions can be planned to meet the requirements of different usage, providing various sizes and types of dwelling units. The sizes of the free spaces which are required in apartment houses are largely related to the social and income levels of the occupants. We are aware of the potential danger of an over-emphasis upon

minimum standards without a corresponding concern for social, human and cultural values.

The minimum dimensions presented in various plans for the standard modular units adhere to the standards permitted by the F. H. A.[5]

5. See Minimum Property Standards for Multifamily Housing, Federal Housing Administration, Washington, D. C., 1963.

## 5. SELECTION OF THE SUPPORTING SYSTEM OF MODULAR UNITS FOR MULTI-STORY BUILDINGS

The solutions possible for building multi-story units with modules fall into two categories:

1. Dependent structures: stacking of housing units.
2. Independent structures: a separate structural frame, megastructure or component is incorporated to support each module independently of all other modules.

Each category has its own advantages and disadvantages. The independent system was investigated and discarded in favor of the dependent structures for the following criteria:

1. The dependent system provides faster and more efficient on-site construction. The units can be placed directly on foundation walls, precast frames, or on elevated concrete platforms. The independent structures increase on-site work because of the need for additional structure.
2. Simple construction methods. The units are stacked in place and field-welded at the points of connection (joining the top and bottom parts of the columns of the modular frames to form structural continuity). The independent systems require elaborate connecting procedures and equipment, especially in the case of utilization of the suspending method.
3. Low site equipment costs. Only lifting cranes appropriate to handle the units are employed.

However, in the dependent system, the bottom units support the units above. This implies that theoretically the bottom modules must be stronger than those on top. In order to achieve an efficient material economy, each additional structure of modules should be designed to carry less weight. In the presented structural frame, the thickness of the columns varies with the imposed load. With respect to this approach, the system does not offer a unique design in the structure of the modular unit.

Another disadvantage of the dependent system is the lack of long-range planning flexibility, because one module cannot be removed without first moving those it supports. The concept of a permanent frame with replaceable modules seems simple, but has not yet become a reality.

# 6. THE DEVELOPMENT OF DWELLING PLANS

## 6.1 Housing System Planning (See Figs. 8 - 46)

The size, shape and building system of the dwelling modules to form living units have direct implications for the possible combinations of the modules or floor plans. The standard modular units were designed, and by combining these modules horizontally or vertically, in parallel rows, at right angles to one another, and/or in shifted alignments, dwelling unit plans or combinations could be achieved in various sizes and configurations (accommodating efficiency units, one-bedroom to four-bedroom units (see item 6.5)). Again, by arranging these dwelling unit plans to form buildings, a variety of dwelling types as well as building forms, both high-rise and low-rise, could be provided.

It can be concluded that the planning of the building must be developed with the building system in mind, and vice versa. Changes in the building system affect the plans, and planning requirements affect decisions concerning the configuration of the building system.

## 6.2 Housing Types (See Figs. 47 - 80)

The system can fulfil the needs of any type of housing. The following housing types can be provided, resulting from the arrangement of the standard unit plans:

1. single family house, detached;
2. single family house, attached;
3. multifamily low-rise (with or without corridor);
4. multifamily high-rise

For all the building types the standard modular units are used. The only required adjustment of each module is the appropriate additional part which functions as the corridor or common means of access. The standard vertical circulation modules (accommodating elevators, staircases, ventilating ducts, waste disposal units, janitor's rooms, electric and telephone closets) are designed to fit into each housing type to form vertical access and lateral load resistance. There is evidence in our design to indicate that the presented system of housing is highly adaptable and adjustable in terms of density (dwelling units per acre), relation to site and buildable topography conditions. The size of the site would impose no limitations, as the system can generate various housing types - single family houses, and high and low rise apartments, as mentioned.

6.3 <u>Spatial Quality</u>

It is necessary that adequate housing quality be provided, yet reconciled with minimum cost by the efficient use of space. Space needs were determined by family size, functions of day-to-day living, and the normal possessions of a family. Dwelling units were planned to contain space sufficient to accommodate appropriate furniture or equipment for each habitable room. Various sizes of dwelling units accommodate the area requirements which fall within the standard established by taking averages of existing plans of units for low to moderate income families (see item 6.5 and Appendix A).

We emphasize indoor-outdoor relationships by providing optimal opening to the dwelling units. The relationship to outdoor areas is particularly necessary for single-family houses and low-rise buildings; terraces and balconies should be provided.

## 6.4 Circulation within Dwelling Units

It is imperative that the circulation pattern throughout a living unit should be satisfactorily planned. The arrangement of rooms within a unit should have a proper relationship one to another, and also provide reasonable privacy. The entrance to each unit should be appropriately located to achieve privacy and compactness of circulation, leaving space uninterrupted and saving floor area; to fulfil these requirements we decided that the entrance should be centrally located so that it is between the bedroom zone and the living area.

## 6.5 QUANTITATIVE ANALYSIS OF AREAS OF DWELLING UNIT PLANS

(See Appendix A for comparison with areas of existing dwelling units)

Net living area (N): Habitable space, excluding circulation, bathroom, storage, closets, and exterior space. Measurements are based upon dimensions between partition surfaces.

Gross area (G): Total square footage, excluding exterior space and public building circulation and service.

FHA: Minimum allowable area.

| UNIT PLANS | LR | DR | LR-DA | K | BR (primary) | BR (secondary) | N | G | N/G |
|---|---|---|---|---|---|---|---|---|---|
| 0-BR (FHA) | | | 240* | 40 | | | | | |
| PLAN A | | | 243* | 51 | | | 294 | 386 | 76.2 |
| 1-BR (FHA) | 160 | 100 | 200 | 40 - 60 | 120 | | | | |
| PLAN B | | | 200 | 62 | 169 | | 431 | 628 | 68.6 |
| PLAN C | | | 210 | 62 | 210 | | 482 | 676 | 71.3 |
| PLAN D | | | 200 | 62 | 198 | | 460 | 676 | 68 |
| PLAN E | 180 | 158 | | 62 | 169 | | 569 | 798 | 71.3 |
| PLAN F | 180 | 158 | | 62 | 210 | | 610 | 845 | 72.1 |

* Including BR.

| UNIT PLANS | LR | DR | LR-DA | K | BR (primary) | BR (secondary) | N | G | N/G |
|---|---|---|---|---|---|---|---|---|---|
| PLAN $G_1$ | | | 390 | 62 | 198 | | 650 | 845 | 76.9 |
| PLAN $H_1$ $H_2$ $L_2$ | | | 465 | 70 | 169 | | 704 | 966 | 72.8 |
| 2-BR (FHA) | 160 | 100 | 200 | 60 | 120 | 80 | | | |
| PLAN G | | | 200 | 62 | 198 | 130 | 590 | 845 | 69.8 |
| PLAN H $H_3$· I J | | | 315 | 70 | 169 | 124 | 678 | 966 | 70.1 |
| PLAN K | 180 | 158 | | 62 | 198 | 130 | 728 | 1014 | 71.8 |
| PLAN L $L_1$ M N | | | 315 | 70 | 176 | 124 | 685 | 1014 | 67.5 |
| PLAN O | | | 200 | 62 | 238 | 136 | 636 | 1014 | 62.7 |
| PLAN P | 180 | 158 | | 62 | 238 | 136 | 774 | 1183 | 65.4 |
| PLAN $Q_2$ | | | 464 | 70 | 238 | 136 | 908 | 1352 | 67.1 |
| 3-BR (FHA) | 170 | 110 | 220 | 70 | 120 | 80 each | | | |
| PLAN Q $Q_1$ R S | | | 315 | 70 | 238 | 136 - 124 | 883 | 1352 | 65.4 |
| PLAN $T_1$ + $T_3$ | | | 645 | 80 | 179 | 149 - 149 | 1202 | 2028 | 59.2 |
| 4-BR (FHA) | 180 | 120 | 230 | 80 | 120 | 80 each | | | |
| PLAN $T_1$ + $T_2$ | | | 447 | 80 | 198 | 179 - 149 - 149 | 1202 | 2028 | 59.2 |

# 7. STRUCTURE AND COMPONENT DESIGN OF MODULAR UNITS

## 7.1 Analysis of the Materials and Construction Methods

It was decided that the stacking of modular units should be the building system. The modules were thus designed to serve this construction method. Each module consists of a structural steel skeleton enclosed by a non-load-bearing material. Since only the frame itself is load-bearing, any of the sides, the top, or the bottom could be omitted without affecting the structure. The steel-framed module provides for freedom in location of spatial connections, windows and other openings.

Each modular unit measuring 13' 0" x 13' 0" is composed of four 6" x 6" columns of steel tube. The units measuring 13' 0" x 26' 0" have eight 6" x 6" columns. The units, as designed, can be stacked to a maximum of twenty stories.[6] The transfer of vertical loads from unit to unit is accomplished in direct compression through the cap and base plates at the ends of the columns. Each column has the same outside dimensions throughout the whole height of the building; only the thickness of the steel tube is varied according to structural requirements.

The steel columns require 3-hour fire rating and thus are surrounded by 3-layer 5/8" Firecode Wallboard laminated and screw attached to metal corner beads, or one layer of 1.5/8" mineral fiber.

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6. The limit is set by the bearing capacity of the steel column of the modular unit at the lowest level.

Floor (2-hour fire rating)

Gypsum floor planks 2" thick with metal edges are supported by traverse open-web bar joists. Bar joists are selected to allow the penetration of ventilating ducts, pipes for heating and plumbing and space for electric raceway. The bar joists which require 2-hour fire rating are protected by floor and ceiling material.

During installation, the metal edges of the floor planks are welded to the supporting steel joists to form a rigid integral structural member. Mastical underlayment compound of at least half-inch thickness provides good sound control and can be covered with a variety of finished flooring materials.

Ceiling (2-hour fire rating)

Since the bar joists of the floor of the upper box have to be fire-protected from the ceiling of the lower unit, this ceiling is provided with the same 2-hour fire rating. The ceiling, which also functions as the roof of the box during shipping and handling, is structurally independent of the floor components. One layer of $\frac{1}{2}$" Firecode "C" Wallboard is attached to the ceiling structure which comprises metal furring channels and steel channels traversely placed to add rigidity to the steel frame module.

Side and Back Partitions (2-hour fire rating)

The partitions, which are non-load-bearing, consist of double layers of $\frac{1}{2}$" Sheetrock Firecode "C" with steel studs. $1\frac{1}{2}$" Thermafiber Sound Attenuation Blankets are stapled between the studs for the adjoining partitions between dwelling units and for exterior partitions. Exterior panel surfaces are sprayed with latex stucco finish.

Interior Partitions (non-combustible material)

Interior partitions are constructed by the same method as the side partitions, but are composed of one layer of gypsum board without any insulation.

Glazed Wall Panels (non-combustible material)

A steel or aluminum window frame with $\frac{1}{2}$" insulating glass is installed together with the heating/air-conditioning elements as an integral part of these panels.

Roofs ($1\frac{1}{2}$-hour fire rating)

For the top modular unit of a building, a roof having the same construction system as the floor of the unit was considered. This idea was abandoned, and a corrugated metal deck spanning steel channel was chosen because of its lighter weight. Additional elements such as rigid insulation on the metal deck, $\frac{1}{2}$" gypsum board ceiling, flashing and built-up roofing, are factory built. Only the flashing between units is field connected.

Interior Finishing

All interior work, including furnishings, is installed in the manufacturing plant:

Flooring

Carpet with integral pad for living, dining and family rooms, bedrooms, circulation spaces, and building corridors.

Vinyl asbestos for kitchens and bathrooms.

Interior Partitions

Painted gypsum wallboard applied to metal studs.

Ceramic tiles for tub and shower compartments.

Ceilings

Painted gypsum panel.

Doors, metal frame

Wood for openings within a dwelling urit.

Hollow metal for fire-rated doors.

Stair Units

Exposed concrete with wood handrails.

## 7.2 Weight Calculation of Modular Unit

The unit measuring 13' 0" x 26' 0" x 9' 6" was selected for weight calculation.

| Item | Pounds | Tons |
|---|---|---|
| Ceiling (13' 0" x 26' 0") | | |
| One layer of ½" Firecode "C" | 684.45 | 0.34 |
| 4" - 5" steel channels, 1½" metal furring | 1028.40. | 0.51 |
| Column | | |
| 76 linear feet, eight 6" x 6" steel tubular column with 1. 5/8" mineral fiber | 1749.52 | 0.87 |
| Exterior gypsum partition, 60 linear feet | | |
| 2 layers of ½" Firecode "C" | 2880.00 | 1.44 |
| 2½ metal studs, runners, insulations | 302.40 | 0.15 |
| Glazed panel, 12' 0" x 7' 6" | | |
| ½" insulating glass, aluminum frame | 768.00 | 0.38 |
| Floor, 13' 0" x 26' 0" | | |
| 2" gypsum floor plank with floor finish | 9126.00 | 4.56 |
| 8" open web floor joists, 7" channel beam | 1016.40 | 0.51 |
| Dead load of a unit without kitchen and bathroom | 17555.17 | 8.78 |
| Approximate weight of a 2-bath unit (each 5' 0" x 7' 0") or kitchen (9' 0" x 8' 0") | 1000.00 | 0.50 |
| Dead load of a unit with 2 bathrooms or a kitchen | 18555.17 | 9.28 |
| Live load, 40 lbs/sq. ft. | 13520.00 | 6.76 |
| Dead load + live load | 32075.17 | 16.04 |

For units measuring 13' 0" x 26' 0" x 9' 6", the weight varies according to different layouts between 15.5 and 16 tons.

## 8. MECHANICAL

All vertical chases serving kitchens, bathrooms and heating and ventilating systems are located along the corridor, or are accessible from the outside of dwelling units, and are provided with access panels. The size of the chase can accommodate all the piping required for heating, plumbing and electric risers. To avoid problems of alignment and difficulties in connection, it is decided that all vertical pipes shall be installed on the site, only the pipes from each fixture being installed in the factory.

### 8.1 Heating

Either of the two following heating systems is recommended: a fan-coil unit which also provides air-conditioning for the dwelling unit, or a baseboard unit with forced water system. Spaces for additional, independent, electrically-operated air conditioning units are provided to the units with baseboard heating system.

For multistory buildings, hot water is generated from boilers, located in a roof penthouse boiler room, or in the basement, through supply and return riser systems into the thermostatically controlled fan-coil units or into the finned tubes of the baseboard units, and through distributing piping in the core to corridor heating-ventilating units.

For a single family house, a boiler located in the service section of the carport module generates hot water through supply and return piping to the heating units in each module.

Fan-Coil Units. The 2-pipe fan-coil unit is plant-installed in a cabinet below the window sill in each module as a part of the glazed wall panel. The principal functions of the units are to heat, cool and ventilate a space by the introduction of outdoor air through a small grill. Thus the utilization of central station air handling equipment or ductwork can be eliminated. Chilled water from a central refrigeration plant is circulated through the unit coils to cool the air during the summer. Hot water from a boiler is supplied to the same unit coils during the winter. The system is selected because it offers economy of operation and individual room temperature control, providing adequate comfort in heating and air-conditioning for dwelling units.

All the horizontal supply and return pipes are located under the floor through open web bar joists and are field-connected to the vertical supply and return risers in the vertical chases. Field connections have also to be made at the wall sleeves provided between adjacent partitions of the modular units.

Baseboard Units. The finned-tube type baseboard unit with forced water system is selected. The unit consists of copper tubing with aluminum fins that is concealed by a long, low sheet-metal enclosure or cover. A major portion of the heat is transferred to the room by convection. Units are concentrated below the glass or they are installed along as much of the exposed wall as possible to obtain optimum comfort for room occupants. Baseboard units are practical, especially in the case of walls in which there are large glass-to-the-floor panels. Other reasons for selecting baseboard units are: they are inconspicuous; they offer a minimum of interference with furniture placement; they distribute heat near the floor and tend to provide uniform temperature throughout the room.

## 8.2 Ventilating

The supply and return duct distribution systems located in the core area provide ventilation and heating to the corridors on each floor and also supply fresh air to the apartments with baseboard units.

Exhaust from each apartment kitchen and toilet is accomplished separately by the use of an individual small centrifugal fan unit with integral intake louver appropriately located. The exhaust is discharged through horizontal ductwork, located under the floor of the upper unit, leading to the building perimeter. Alternatively, the exhaust from the kitchen is led through an absorption chamber within the kitchen unit; the required ductwork is reduced but maintenance costs are higher.

Exhaust from the kitchen and toilet in each modular unit of a high-rise building is individually handled simply because the required size of vertical ventilating ductwork is too big to accommodate the modular unit.

## 8.3 Plumbing

The entire bathroom and kitchen are assembled in the factory, including all plumbing fixtures and piping in the wall chase behind the fixtures (excluding the vertical risers which are field-installed).

A riser system, which consists of one set of risers for each vertical chase, is provided for apartment toilet and kitchen equipment. This implies that the risers in each modular unit on the same floor work independently.

Cold water is conducted through up-feed risers by a water pressure booster system to the apartments and additionally to the rooftop mechanical room. The cold water is heated by a hot water generator in this room and is led to the apartments through a downfeed riser system. Hot water in the risers is maintained by a recirculating pump in the mechanical room.

One set of waste and vent risers, size in accordance with code, handles the waste from each modular unit.

All field-installed risers are joined together under the platform level or in the basement where the waste risers are discharged out of the building. Vent risers terminate above the roof in an approved manner.

## 8.4 Electrical

Power is distributed from the master switchboard located in the basement to various lighting and power panelboards in the building as required. The power is fed through a series of risers in the toilet room vertical chase, one for each stack of apartments, to an apartment load center located on the kitchen wall. Suite intercom house telephone and public telephone wiring is also provided by riser systems close to the power riser.

All the wiring, outlets, switches and fixtures in each modular unit are installed in the factory. The risers for each floor-to-floor segment for all systems, except public telephone, are provided as coiled-up flexible cable requiring only field connection to the riser splicebox in the floor below. Horizontal connections between modules in each apartment are made on site with flexible cable through sleeved openings in the junction partitions just above the floor of the units. Horizontal wiring in each module is located under the floor through the open web bar joists.

## 9. ACOUSTICS

In the design process we considered noise transmission as one of the most acute problems for livable housing. Acoustical considerations in the developed system are concerned with airborne sound transmission and impact noise transmission. The transmission of airborne sound between adjacent units is prevented by the $1\frac{1}{2}$" Thermafiber Sound Attenuation Blankets with double layers of $\frac{1}{2}$" gypsum board on one side of the adjoining partitions. The total STC achieved is 54.

The other most critical problem is the transmission of impact noise through the floor structure. To counteract this problem, a resilient floor finish material such as carpet is extensively used to reduce and absorb impact noises. The 1.1/8" Mastical Underlayment Compound over $\frac{1}{2}$" USG Mineral Fiber Sound Deadening Board, together with the 2" gypsum floor plank will offer STC 48 and INR-4.[7]

However, it should be noted that the acoustical characteristics of the building as a whole depend not only on the elements which make up the building, but also upon the details of the assembly of those elements. In this regard, sound transmission between apartments can be minimized by maximizing the degree of physical separation between the floor of one unit and the ceiling of the unit below (the only points of contact between the upper and lower units are at the column connections) and between the side partitions of each unit.

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7. The FHA minimum sound transmission requirement is STC 45 and INR-2 for floors separating living units. See Minimum Property Standards for Multifamily Housing, Federal Housing Administration, Washington, D.C., 1963, pp 89, 90.

## 10. FACTORY FABRICATION SEQUENCE OF HOUSING UNIT

(See Figs. 5 - 7)

1. Floor and ceiling structural components separately framed in jigs. Gypsum ceiling fixed to the ceiling structure.

2. Columns, floor and ceiling structures connected to form a three-dimensional unit.

3. Gypsum floor planks set and welded to the open web bar joists. Layers of Mineral Fiber Sound Deadening Board and Mastical Underlayment Compound added over floor planks.

4. Side and interior partition frames with top and bottom runners made in jigs secured to their positions.

5. Wiring, piping, and ducts installed.

6. Gypsum wall panels and insulation fixed.

7. End window frame panel and heating element installed.

8. Bathroom and kitchen fixtures installed.

9. Move to finishing shop, apply finished floor and paint to wall panel and ceiling.

10. Glazing and water-proofing.

11. Openings temporarily braced and the whole unit protected with polyethylene.

12. The unit stored or loaded on truck for transport to construction site.

## 11. HANDLING AND SHIPPING OF MODULAR UNITS

Handling and shipping of the modular units is seen as a major factor in determining the ultimate economy of the system. Because of the volumetric size of the units and possible limitations of site storage area, transportation must be organized efficiently in order to minimize the number of times a unit is handled.

It has been pointed out that a 300-mile radius is the approximate economic cutoff point.[8] Thus a factory can economically serve any project within these distance limitations. The costs of highway transportation are similar to the costs of transporting conventional mobile homes. It has been estimated that the mobile home industry delivers a unit within a radius of 300 miles from the factory at a cost of 50 cents a mile.

The transportation constrainst lie not only in the costs involved, but also in the limitations imposed by the available trucking facilities and the regulations of state highway authorities. The present economical transportation mode has been limited to trailer trucks. Most of the truck beds are smaller than the modules they carry. The truck should be equipped with a base of rigid steel frame to support the entire size of the unit, to avoid tension in the ceiling structure and compression in the floor during transit.

The completely fabricated units have to be protected during transportation and storage out of doors. The best solution to protect the exposed steel ceiling structure and the ceiling itself is to completely cover the box with canvas or polyethylene tarpaulins.

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8. See Research Report No. 8, a report on the Factory-Produced Dwelling Module, The New Building Block, Center for Housing and Environmental Studies, Cornell University, Ithaca, New York, p. 245.

# 12. ERECTION PROCEDURE

## 12.1 Lifting (See Figs. 86, 87)

A lifting frame is required to facilitate erection procedures. The frame consists of a pipe lifting frame with four suspension points at the corners and with six lifting bolt-pick-up points connected to the lifting devices at the top of the tubular columns. Six pick-up points are needed to reduce the bending moment during lifting. Deformation can be avoided because the structural steel frame is always subject to vertical load action.

## 12.2 Connection of Modular Units

### Structural Connection (See Figs. 99 - 103)

The completed building comprised of modular structural steel boxes represents a rigid steel structure which implies that the boxes have to be tied together both horizontally and vertically to give sufficient lateral stability and direct vertical load transmission.

In the presented system the only points of connection for the modular units are at the top and bottom of each column to minimize field welding. A cap plate with an oversized hole for each 6" x 6" tubular column is welded to the top of the column at the factory; similarly, a base plate with a tapered spigot, the size of which corresponds to the hole of the cap plate, is factory-welded to the bottom of the column. The hole and the spigot serve to align the columns such that each column is directly above the preceding column.

When two adjacent boxes are in place, the adjoining cap plates are field welded together serving as a horizontal tie. When the box above is lowered into position, the base plate and the cap plate are welded together to serve as a vertical tie. The inevitable problem encountered with the connection of the boxes is the inaccessibility to welding points of adjacent units. Two methods of placing the units were investigated. In welding diagram A, only one side of the exterior wall in the long direction is exposed for welding during the erection process; in order to achieve rigidity in both directions along the longitudinal direction of the building, the boxes are placed in opposite directions on each level of boxes. In welding diagram B, on each level the boxes are placed on top of alternate units below so that both sides of the upper boxes are accessible for welding. Then units are placed in the alternate spaces; these units cannot be welded at the lower connection points, but they can be welded at the upper connection points. In both systems, the boxes are tied together horizontally and vertically to form a thoroughly rigid structure.

Interior Connections

After the two boxes have been structurally connected, the interior floor finishing at the connection is accomplished by taping the trimmed carpet. A caulked patch is made where the two partitions or ceilings meet.

Exterior Connections

Exterior finishing is done by caulking the vertical and horizontal exposed joints between the boxes along the facade and exposed end walls. On the roof level, the flashings between two boxes are connected; patches are made in the roof felt, if necessary, to provide a continuous roof covering.

## 13. CONCLUSION

Many architects today are working towards the realization of lower-cost factory-produced housing. We also have attempted to seek solutions to reach that goal. We have made every effort to be thorough, within time limitations, in developing the presented industrialized housing system to a point where it can make a significant contribution.

We have realized that certain intrinsic problems exist in the industrialization of housing if steel is used as the basic structural material of the modular framework. Many studies have pointed out that housing construction offers a tremendous potential market for steel. We suggest that close collaboration between the steel industry and manufacturers of other materials, particularly gypsum products (which process both the fireproofing and sound attenuation properties), is required before any significant progress can be made in the development of industrialized housing systems.

The steel-framed modules would be applicable to both high and low rise constructions. However, most of the technology in housing is directed at walk-up buildings. The cost of experimenting with a multistory building is so formidable that sponsors stay away from such projects. High-rise construction is inevitable and should be emphasized. To develop truly industrialized housing requires the kind of business enterprise that can afford to experiment.

It is apparent that with industrialized building the process from initial conception to final execution on site is inter-related and that persons concerned with any single aspect of the project must have a thorough knowledge of all other aspects. Members of the design team must appreciate the problems of all the contractors involved to avoid unnecessary difficulties in fabrication, transportation, and erection.

In dealing with an industrialized housing system, what is obviously needed is exploration of some of the technological and economic advantages of the systems approach, but it is equally necessary to have a genuine concern for the potential hazards to human, social and cultural values. As members of a profession to which is entrusted the creation of physical forms of human habitat, we have to recognize the importance of the environment. We have to go beyond what industrialization seems geared to provide, else the environment will suffer. With this approach in mind, industrialized housing systems should provide plenty of variation in design and construction based upon important individual and social factors such as varying life styles, stages in family life cycles, or equally important conditions such as climate, landscape or relation to site. It is our hope that future studies will continue to pay attention to these aspects.

Generally, it can be concluded that at present there does not appear to be any significant technological breakthrough which could be achieved through:

Revision and unification of building codes and transportation regulations.

Close collaboration among architects, engineers and industry to program and design the new systematized housing units.

Recognition of standard dimensions and joints among manufacturers to keep open systems.

Development of new lightweight, multipurpose materials which integrate structural, acoustical, thermal and other physical properties.

Innovation of efficient mechanical and electrical systems to replace the present awkward applications.

Search for economical methods of transportation and erection of modular units through innovative design of equipment and machines.

The systems approach is on the very threshold of a new era of challenge. It awaits those with dedication and vision to implement their endeavors for the benefit of all mankind.

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# 15.1 APPENDIX A

## COMPARATIVE AREA STUDY

The data were compiled from new housing constructed in the Greater Boston area (1952 - 1965), based upon Comparative Housing Study 2, Harvard University.

Net living area (N): Habitable space, excluding circulation, bathroom, storage, closets, and exterior space, in square feet.

Gross area (G): Total square footage, excluding exterior space and public building circulation and service.

| Eff. | | | 1-BR | | | 2-BR | | | 3-BR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N | G | N/G | N | G | N/G | N | G | N/G | N | G | N/G |
| 425 | 640 | 67 | 786 | 1043 | 75 | 841 | 1224 | 69 | 603 | 770 | 78.5 |
| 352 | 517 | 68 | 575 | 889 | 64.5 | 541 | 687 | 79 | 774 | 1168 | 64 |
| 271 | 450 | 60 | 614 | 1038 | 59.4 | 607 | 805 | 75.5 | 1065 | 1866 | 57.2 |
| 348 | 496 | 70 | 475 | 720 | 66 | 418 | 674 | 62 | 1051 | 1575 | 66.8 |
| | | | 632 | 773 | 81.7 | 743 | 1060 | 70 | 763 | 1024 | 72 |
| | | | 516 | 600 | 86 | | | | 710 | 1021 | 69 |
| | | | 492 | 614 | 81 | | | | | | |
| | | | 302 | 433 | 70 | | | | | | |
| | | | 316 | 446 | 71 | | | | | | |
| Average | | | | | | | | | | | |
| 349 | 526 | 66.2 | 523 | 728 | 72.7 | 630 | 890 | 71.1 | 827 | 1237 | 67.9 |

## 15.2 APPENDIX B

### COMPARISON OF HOUSING SYSTEMS
(completely finished modules)

| Project | Material | Dimensions | Area sq. ft. | Struct-ural type | Weight |
|---|---|---|---|---|---|
| Factory-fabricated multifamily housing, Michigan City, Indiana | steel frame<br>steel panels | 12' 0" x 30' 0" x 9' 0" | 360 | stacking | 5 tons |
| Presented system | steel frame<br>gypsum panels | 13' 0" x 26' 0" x 9' 0"<br>13' 0" x 13' 0" x 9' 0" | 338 | stacking | 16 tons |
| Habitat | concrete | 17' 6" x 38' 0" x 10' 0" | 665 | stacking | 90 tons |
| Palacio Del Rio-Hilton Hotel, San Antonio, Texas | concrete | 13' 0" x 32' 8" x 9' 0"<br>13' 0" x 29' 8" x 9' 0" | 424.58 | stacking | 35 tons |
| Typical mobile home | wood<br>plywood panel<br>aluminum siding | 12' 0" x 57' 0" x 10' 0" | 684 | - | 18 tons |

# 15.3 APPENDIX C

## ABBREVIATED NATIONAL BUILDING CODE, 1967

### Article IV. Restrictions within the Fire Limits

### Section 401 Height and Area Restriction

401.1 Limits

| Types of Construction | Height in feet | Area limits for any story in square feet | |
|---|---|---|---|
| | | one story | multistory |
| Fire-Resistive, Type A | No limit | No limit | No limit |
| Fire-Resistive, Type B | 85 | No limit | No limit |
| Protected noncombustible | 75 | 18,000 | 12,000 |

401.2 Height Modifications. Buildings of fire-resistive, Type B, construction may be of unlimited height, provided those portions of the building above 85 feet are used for business or residential.

### Article V. Light and Ventilation

### Section 501 Rooms and Exit Ways

501.2 Habitable Rooms. Every habitable room shall be provided with natural light and ventilation by one or more windows opening onto a street, alley or court.

Such rooms shall be not less than 7 feet wide in any part and shall contain not less than 70 square feet of gross floor area having a clear height of not less than 7 feet, 6 inches for at least 60 square feet of floor area.

When kitchens serving dwelling units are completely enclosed, the gross floor area shall be not less than 60 square feet, and not less than 90 square feet when dining space is included, except that in dwelling units having no bedrooms the gross area of the kitchen shall be not less than 50 square feet.

501.5 Bathrooms. Every bathroom shall be provided with natural or artificial light, and be ventilated by: one or more windows opening on a street, alley or court; or by a vent shaft which extends to and through the roof or into a court; or by a separate duct of non-combustible and corrosion-resistant material, not less than 72 square inches in cross section, extending independently of any duct used for other purposes to and above the roof; or by a ventilating skylight; or by an approved means of direct mechanical ventilation.

501.12 Exit Ways. Every stairway, public hall or corridor in multifamily houses shall be ventilated either by one or more windows opening on a street, alley or court or ventilated by mechanical means approved by the building official or provided with natural ventilation to the outer air by means of a system of vent flues not less than 12 by 12 inches in size.

If windows are used to provide light and ventilation, there shall be at least one window or ventilating skylight having a glazed area of not less than 10 square feet for every 20 feet of length, unless a window is placed at the end of a hall or corridor.

Section 502 Windows

502.1 Glazed Area. The aggregate area of approved glazing material in windows shall be not less than one-tenth of the floor area of the room served by them; in habitable rooms such glazed area shall be not less than 10 square feet, and in bathrooms it shall be not less than 3 square feet.

502.2 Glazing. Only approved wired glass not less than $\frac{1}{4}$-inch thick shall be used for the glazing of fire windows.

502.3 Openings. Windows or other openings required for ventilation shall have an aggregate openable area of at least 50 per cent of the glazed area required for lighting.

Section 530 Vent Shafts

503.1 Size. Vent shafts for every bathroom shall have a cross-sectional area of not less than 72 square inches.

503.3 Air Intakes. Vent shafts shall be connected with a street, alley or court by a horizontal intake at a point below the lowest window opening on such shaft.

Such intake shall have a minimum unobstructed cross-sectional area of not less than 3 square feet with a minimum dimension of 12 inches.

Section 505 Mechanical Ventilation

505.2 Design and Equipment. Except for residence type warm air heating, ventilating and air-conditioning systems, mechanical ventilation systems shall have an approved means of fresh air intake from the outside. Recirculated air shall be supplemented by at least 20 per cent of fresh air.

Article VI. Means of Egress

Section 601

For residential the gross area per occupant is 125 square feet.

602.2 Residential Occupancy. Every story used as a residential occupancy for 10 or more occupants, and every story in a multifamily house having one or more dwelling units above the second story shall have not less than two separate exit ways; except that a single exit way is permitted for multifamily houses of fire-resistive construction not exceeding two stories in height and containing not more than 12 dwelling units, or of heavy timber, noncombustible or ordinary construction not exceeding two stories in height and containing not more than 8 dwelling units.

Section 603 Location

Exit doorways shall be so located that the maximum distance from any point in a floor area, room or space to an exit doorway, measured along the line of travel, does not exceed 100 feet for residential, except that where a floor area is subdivided into smaller areas such as rooms in hotels, multifamily houses, the distance to an exit doorway shall be measured from the corridor entrance of such rooms.

Section 604 Interior Stairways

604.2 Enclosures. Interior stairways in buildings 4 stories or more in height shall be enclosed with partitions of approved noncombustible material having a fire-resistance rating of not less than 2 hours.

In buildings less than 4 stories in height, interior stairways shall be enclosed in partitions having a fire-resistance rating not less than one hour.

604.4 Elevators. Elevators shall not constitute part of a required exit way.

604.5 Width. The unobstructed width of a stairway in a required exit way for 45 or more occupants on any story it serves shall be not less than 44 inches. The unobstructed width of a stairway in a required exit way for less than 45 occupants on each story it serves shall be not less than 36 inches. Handrails attached to walls may project into the required width of a stairway not more than $3\frac{1}{2}$ inches at each side.

The unit of stairway width used as a measure of exit capacity shall be 22 inches. Fractions of a unit shall not be included except that an allowance of one-half unit may be made for 12 inches of stair width added to one or more 22-inch units of stair width.

The aggregate width of exit stairways serving any story shall be based on the number of occupants of that story. The number of occupants per story per unit of exit stairway width for residential is 30.

604.6 Treads and Risers. Risers shall not exceed 7.3/4 inches in height and tread, exclusive of nosing, shall be not less than 9 inches wide.

604.7 Landings. No flight of stairs shall have a vertical rise of more than 12 feet between floors or landings. The length and width of landings shall be not less than the width of stairways.

Article VII. Requirements for Types of Construction

Section 703 Fire-Resistive Construction Type B

703.1 General. All structural members including walls, columns, piers, beams, girders, trusses, floors and roofs shall be of approved noncombustible material.

No pipes, wires, cables, ducts or other service equipment shall be embedded in the required fireproofing of any structural member, nor shall they lie between the required fireproofing and the structural member protected if larger than one inch in diameter.

703.2 Columns and Piers. Columns and piers supporting loads from only one floor or roof shall have a fire resistance rating of not less than 2 hours. Columns and piers supporting loads from more than one floor or roof shall have a fire resistance rating of not less than 3 hours, and columns shall be individually protected.

703.3 Floors. Floors shall have a fire-resistance rating of not less than 2 hours.

703.4 Roofs. Roofs shall have a fire-resistance rating of not less than $1\frac{1}{2}$ hours.

703.5 Beams, Girders and Trusses. Girders and trusses supporting loads from only one floor or roof shall have a fire-resistance rating of not less than 2 hours. Girders and trusses supporting loads from more than one floor or roof shall be individually protected to have a fire-resistance rating of not less than 3 hours.

703.6 Walls. Bearing walls and non-bearing walls shall be of approved noncombustible material. Exterior nonbearing walls with maximum 30% of window to wall area and 3 to 20 feet horizontal separation require the minimum fire-resistance rating of 2 hours.

703.7 Partitions (see 604.2).

## Article IX. Design Loads and General Building Requirements

### Section 902 Live Loads

902.1 Floor Loads. Floors in a building or structure shall be designed and constructed for the greatest loads that probably will be produced by the intended use of occupancy, but in no case less than the following live loads per square foot of area uniformly distributed:

| Occupancy | Live Load lbs. per sq. ft. |
|---|---|
| **Dwellings:** | |
| First floor | 40 |
| Upper floors and habitable attics | 30 |
| **Multifamily houses, tenaments:** | |
| Corridors | 60 |
| Private apartments | 40 |
| Public rooms | 100 |
| **Parking Garages:** | |
| Passenger cars | 50 |

902.4 Stairways and Balconies. Stairways and balconies, both exterior and interior, shall be designed to safely sustain the following loadings taken one at a time:

1. a live load of 100 pounds per square foot;

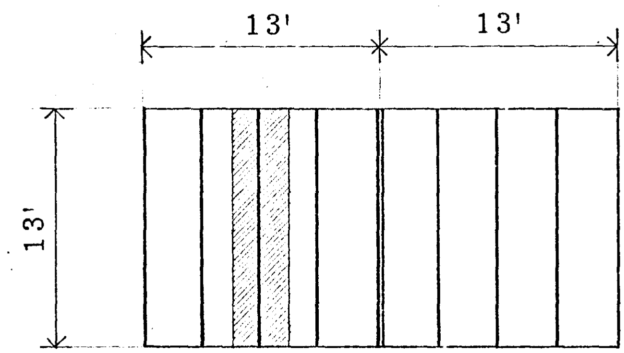
2. a concentrated load of 300 pounds placed upon an area of $2\frac{1}{2}$ feet square.

902.5 Roof Loads. Ordinary roofs, either flat, pitched or curved, shall be designed for a load of not less than 20 pounds per square foot of horizontal projection in addition to the dead load, and in addition to either the wired or other loads, whichever produces the greater stresses.

## 15.4 APPENDIX D

## CALCULATION OF THE STRUCTURAL MEMBERS

Joist




| | | | |
|---|---|---|---|
| Dead load: 24 lbs (gypsum floor) + 3 lbs (finishing) | | = | 27 lbs/sq. ft. |
| Live load: | | | 40 lbs/sq. ft. |
| Floor load on one joist: | $67 \times 13 \times \frac{13}{4}$ | = | 2830.75 lbs. |
| Weight of partition 12' x 8': | | | 449.2 lbs |
| Weight of partition 3' x 8': | $\frac{449.2}{4}$ | = | 112.3 lbs |
| Total load on one joist: | 2830.75 + (112.3 x 2) | = | 3055.35 lbs |
| Load per linear foot: | $\frac{3055.35}{13}$ | = | 235 lbs |
| Approximate joist weight per foot: | | | 4.2 lbs |
| Total load per linear foot: | 235 + 4.2 | = | 239.2 lbs |
| From Table 5-13, joist designation: | 8J2* | | |
| Approximate depth of open-web steel joists: | 8" | | |

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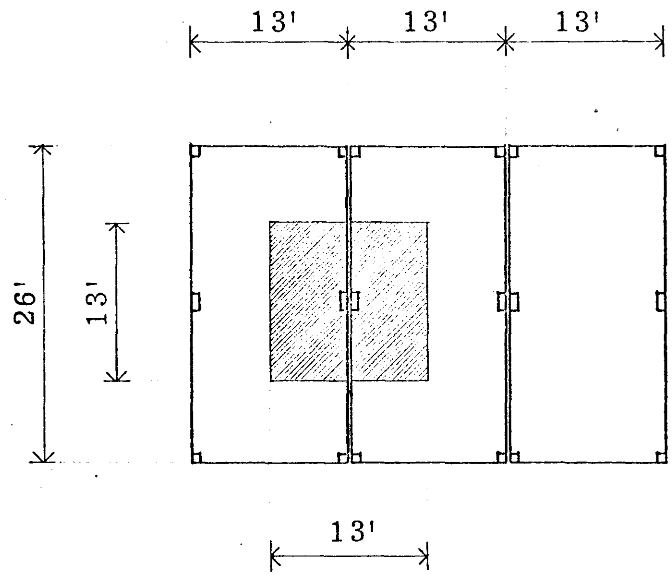
* See Parker, Harry, Simplified Engineering for Architects and Builders, p.140

Column



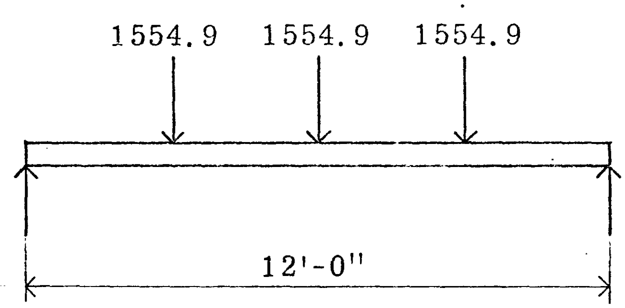

| | | | |
|---|---|---|---|
| From item 7.2, unit weight (live load + dead load): | | | 32,075.17 lbs |
| Load per cubic foot of the unit: | $\frac{32,075.17}{13 \times 26 \times 9.5}$ | = | 10.5 lbs |
| Load on one central column: | 13 x 13 x 9.5 x 10.5 | = | 16,859.75 lbs |
| | | or | 16.86 Kips |
| Allowable stress: | 15 Ksi | | |
| For 20 stories | As = $\frac{16.86 \times 20}{15}$ | = | 22.48 sq. in. |

From Manual of Steel Construction*

Utilizing four 6" x 6" steel tubular columns: As = 26.8 sq. in.

* See Manual of Steel Construction, American Institute of Steel Construction, Inc., p. 3-50.

Floor Beam




Load carried by one joist: $3055.35 + 4.2 \times 13 = 3109.95$ lbs

Point load on beam: $\frac{3109.95}{2} = 1554.97$ lbs

Maximum moment: $\frac{6(1554.97 \times 3)}{2} - 3(1554.97) = 9329.82$ ft. lb.

$f = 24000$ psi

Section modulus: $s = \frac{9329.82 \times 12}{24000} = 4.66\ in^3$

Assume weight to be: 10 lbs/foot

Moment (weight of beam): $\frac{10 \times 12 \times 12}{8} = 180$ ft. lb.

Section modulus: $s = \frac{180 \times 12}{24000} = 0.09\ in^3$

Total $s = 4.66 + 0.09 = 4.75\ in^3$

From Manual of Steel Construction*

Approximate size of floor beam channel: 7" deep, 2" wide

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* See Manual of Steel Construction, American Institute of Steel Construction, Inc., p. I-27.

## 16. PROJECT DRAWINGS


| | Figure Numbers |
|---|---|
| AN OVERALL VIEW OF TYPICAL MODULAR UNIT . . . | 1 - 4 |
| FABRICATION SEQUENCE OF MODULAR UNIT . . . . . | 5 - 7 |
| STANDARD MODULAR UNIT PLANS . . . . . . . . . | 8 - 24 |
| TYPICAL KITCHEN UNIT PLANS . . . . . . . . . . | 25 |
| TYPICAL BATHROOM UNIT PLANS . . . . . . . . . | 26 |
| TYPICAL DOOR AND CLOSET UNITS . . . . . . . . . | 27 |
| TYPICAL DWELLING UNIT PLANS . . . . . . . . . | 28 - 45 |
| TYPICAL CIRCULATION AND SERVICE CORE UNITS . . | 46 |
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| ELEVATIONS AND SECTIONS OF HIGH AND LOW RISE BUILDINGS . . . . . . . . . . . . . . . . | 81 - 85 |
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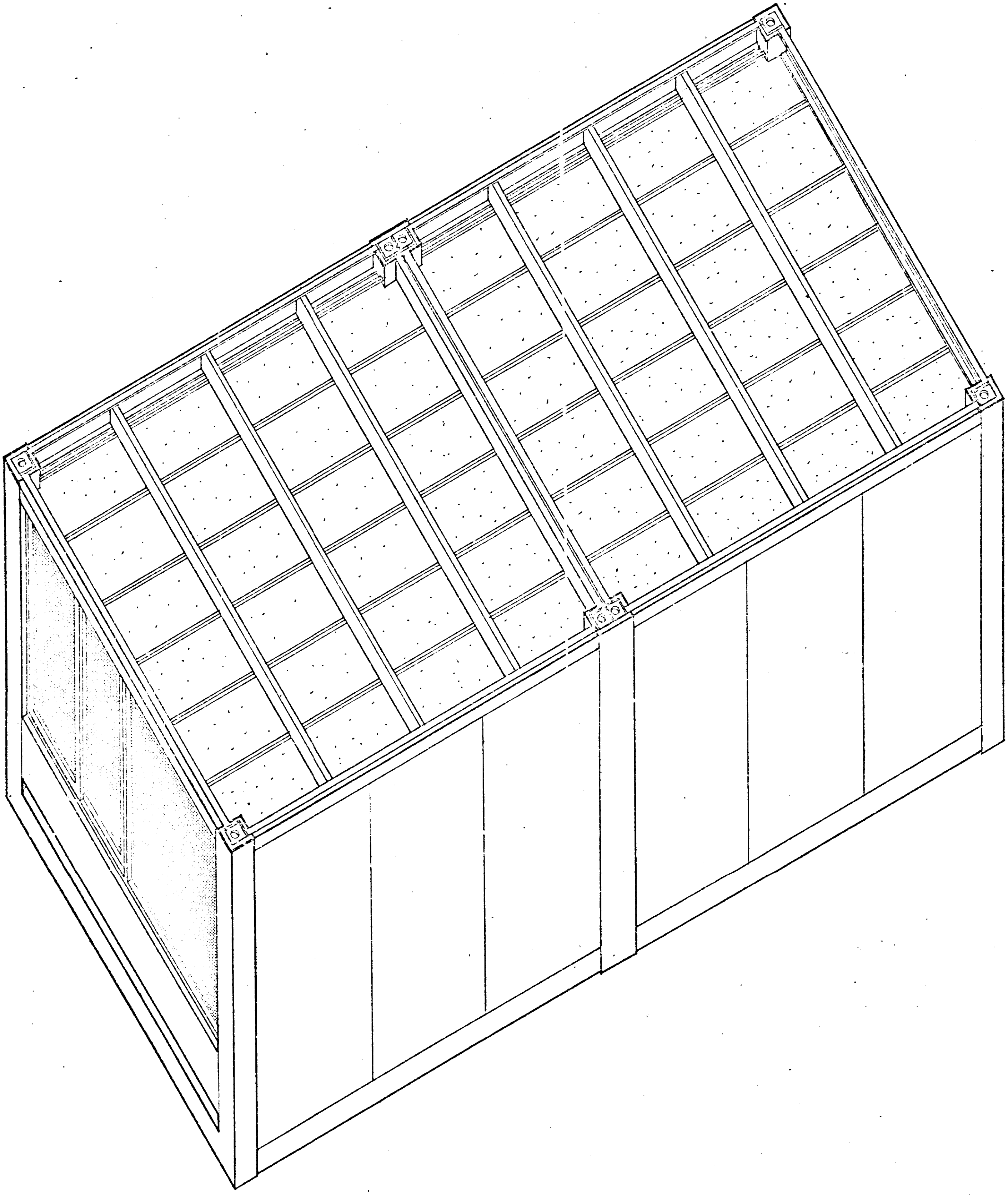
AN OVERALL VIEW OF TYPICAL MODULAR UNIT (Figs 1 - 4)

FABRICATION SEQUENCE OF MODULAR UNIT (Figs. 5 - 7)

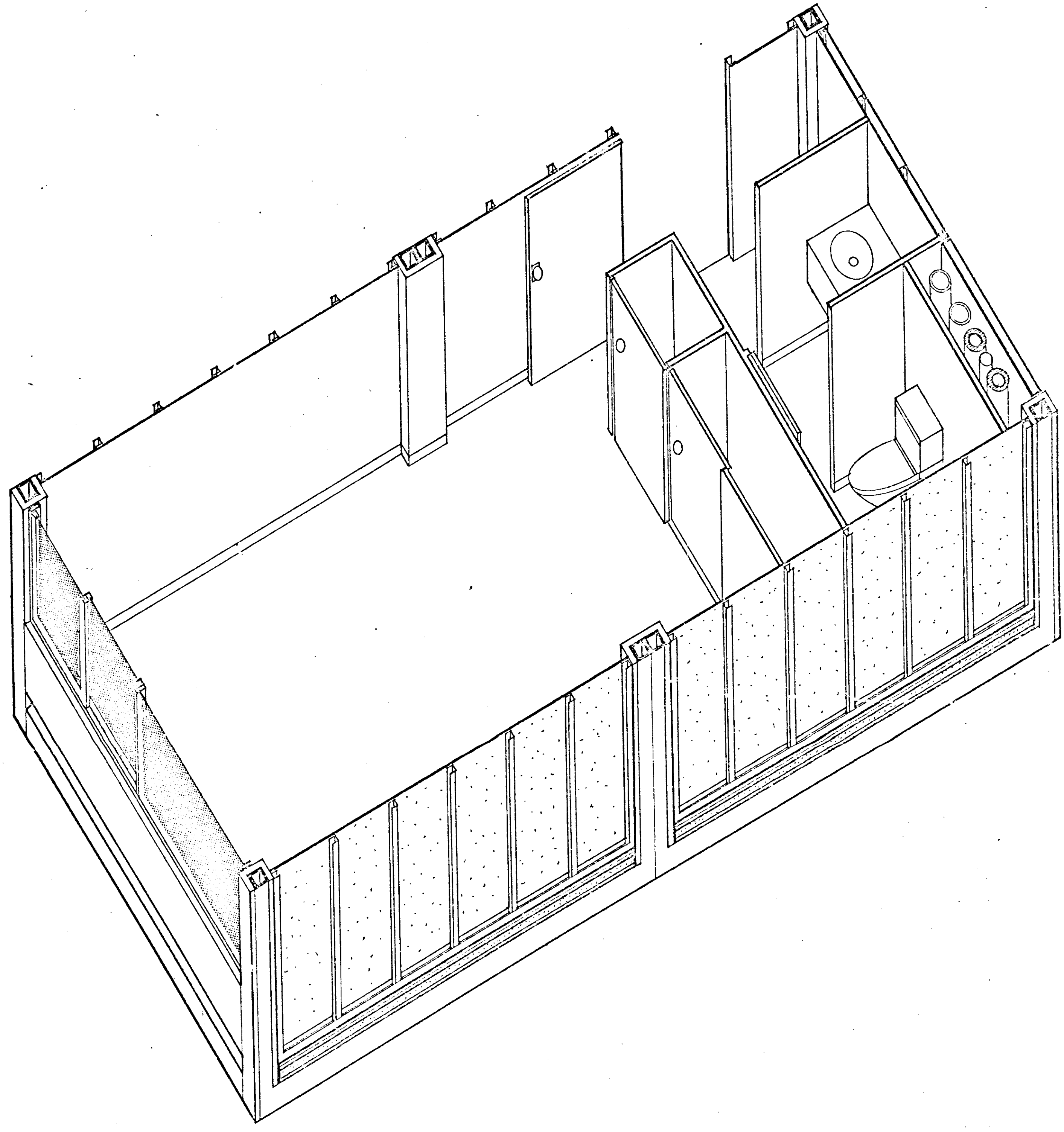
FIG. 1



SCALE $\frac{1}{4}''$ = $1'-0''$

COMPLETED UNIT

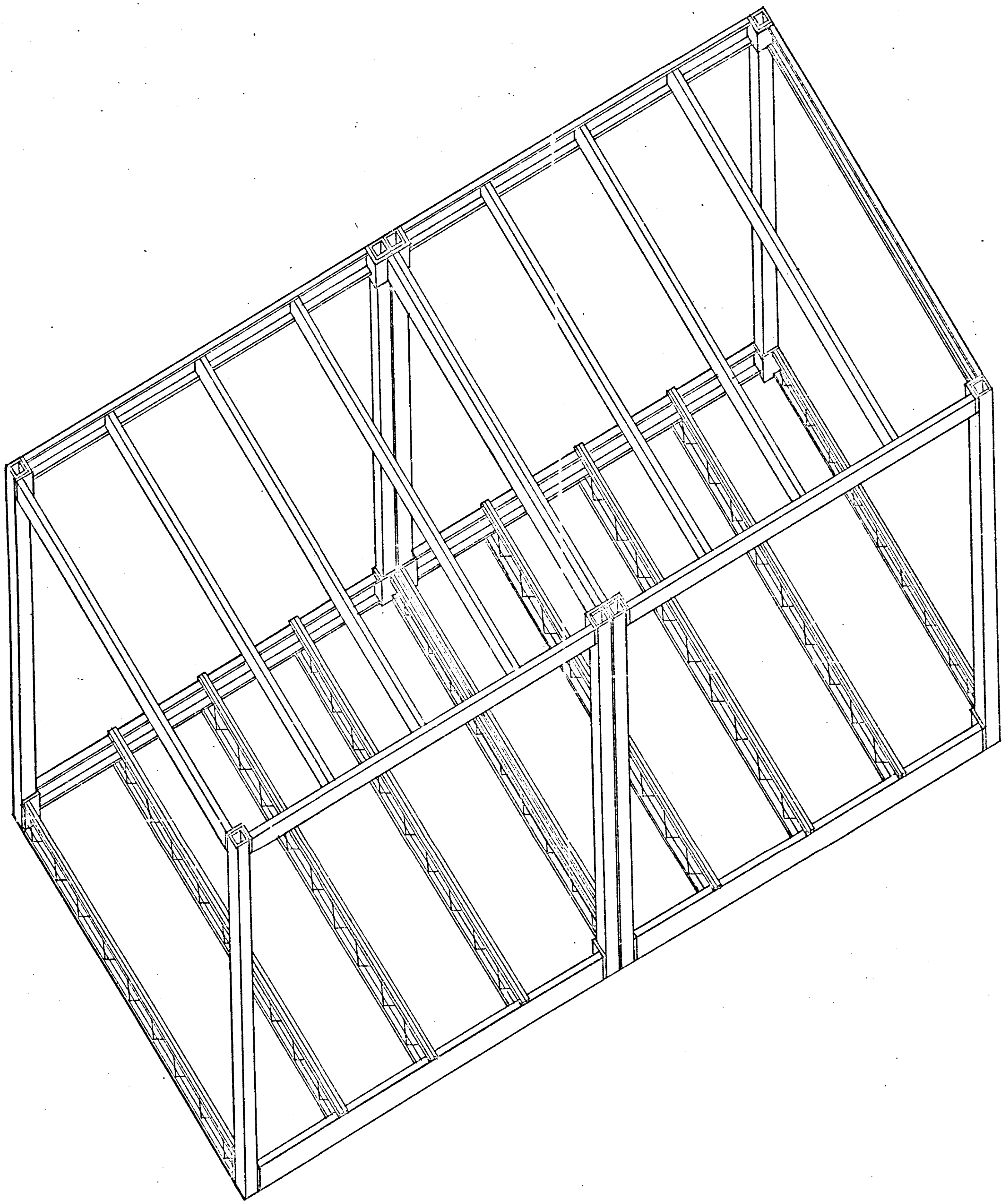
FIG. 2



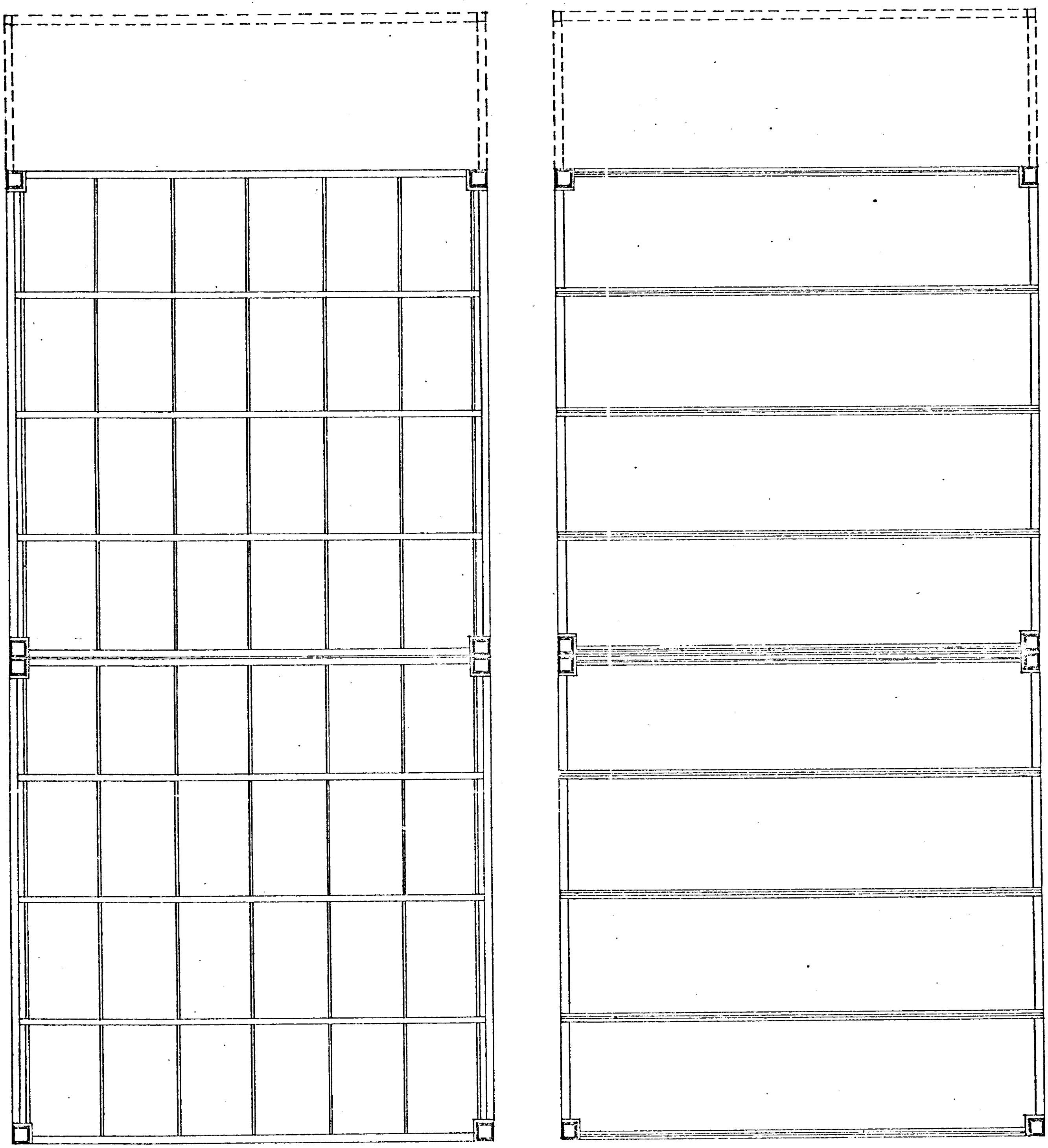
SCALE $\frac{1}{4}''$ = 1' - 0"

UNIT CONSTRUCTION

FIG. 3



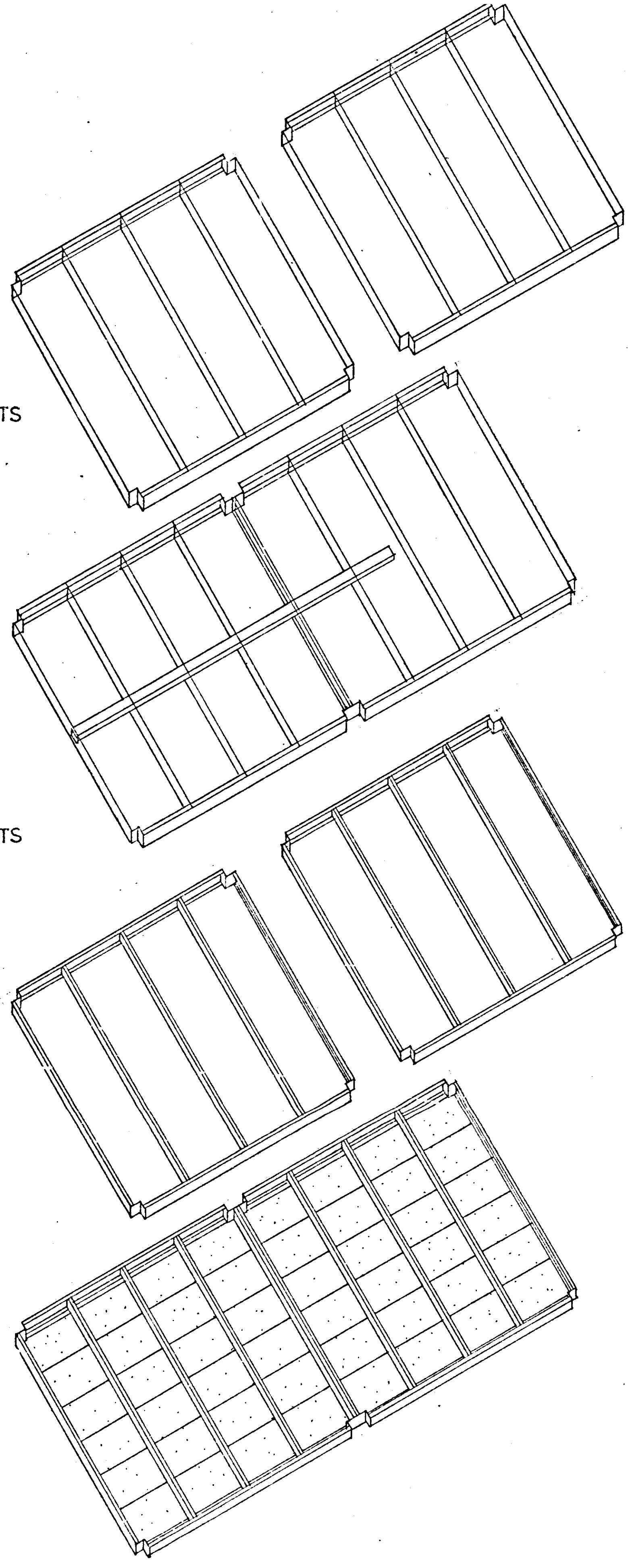
SCALE $\frac{1}{4}''$ = 1' - 0"  UNIT STRUCTURAL FRAME



PLAN

SCALE $\frac{1}{4}'' = 1'-0''$ CEILING AND FLOOR FRAME

FIG. 5



FLOOR STRUCTURAL COMPONENTS
FRAMED IN A MODULE OF
12'-8" x 12'-8"

VENTILATING DUCT INSTALLED
THROUGH OPEN WEB BAR JOISTS

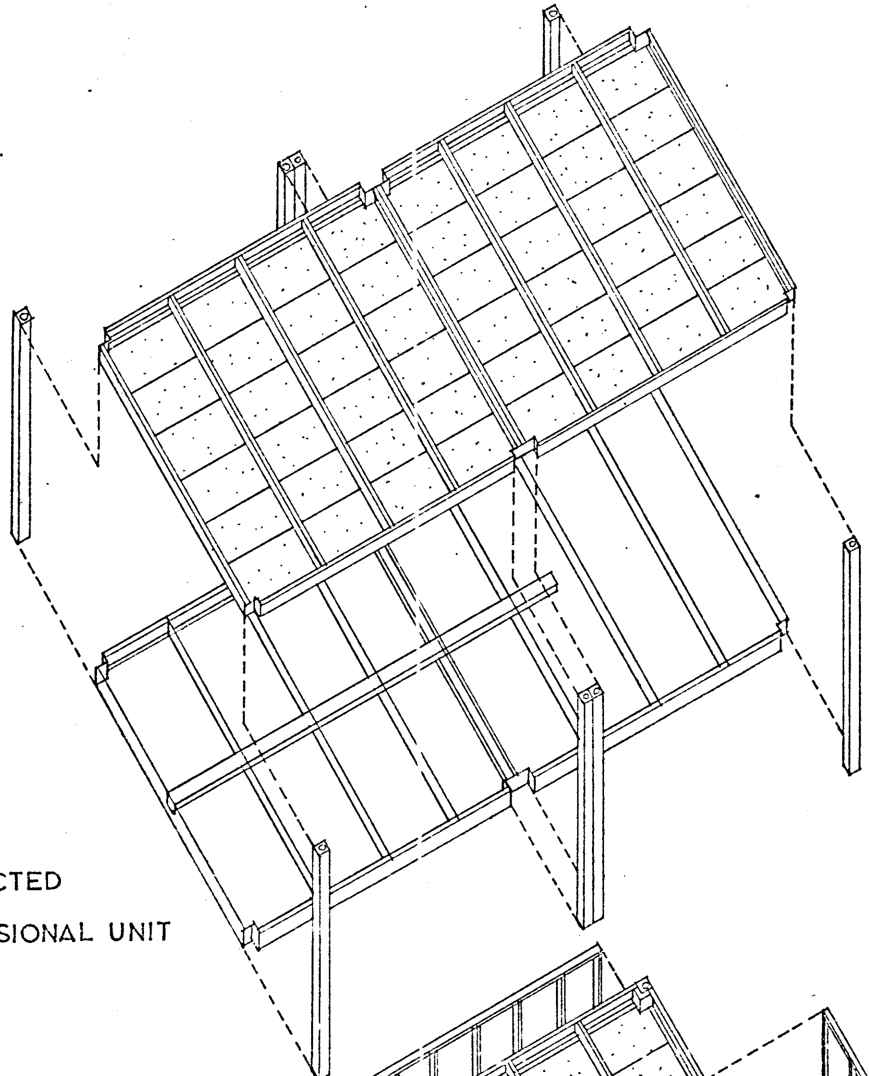
CEILING STRUCTURE FRAMED
IN THE SAME MANNER AS
FLOOR STRUCTURE

GYPSUM CEILING FIXED
TO THE CEILING STRUCTURE

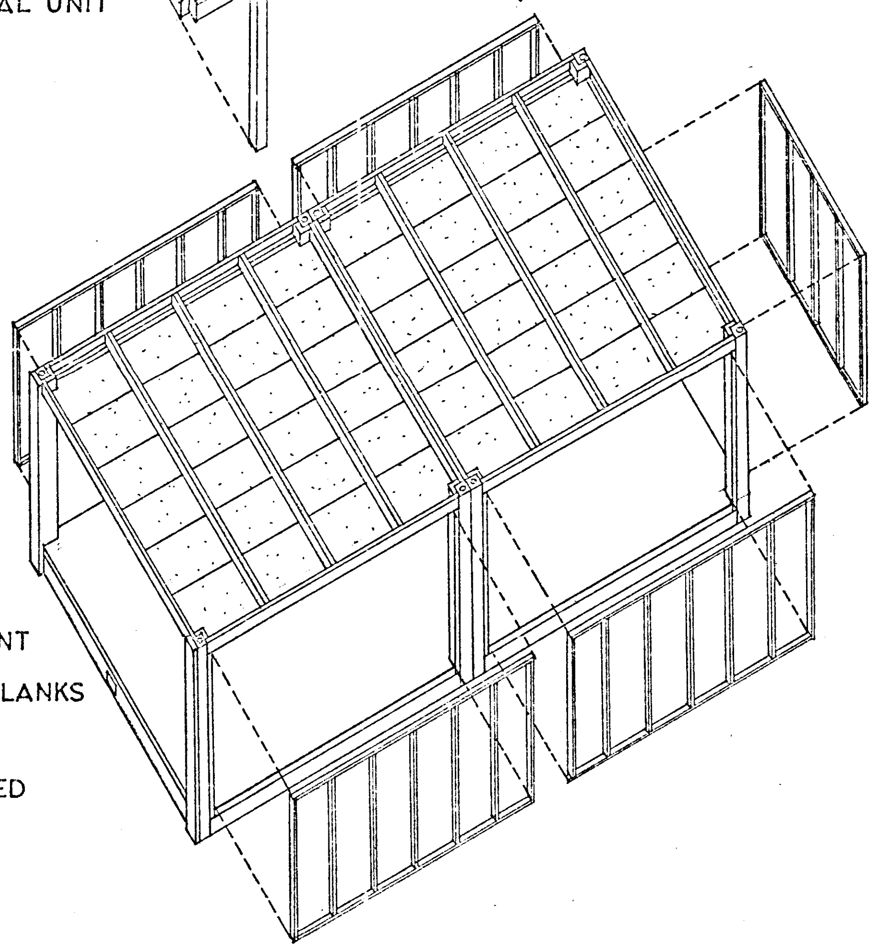
SCALE $\frac{1}{8}$" = 1'-0"

UNIT CONSTRUCTION

FIG. 6



COLUMNS FLOOR AND
CEILING FRAMES CONNECTED
FORMING A THREE-DIMENSIONAL UNIT



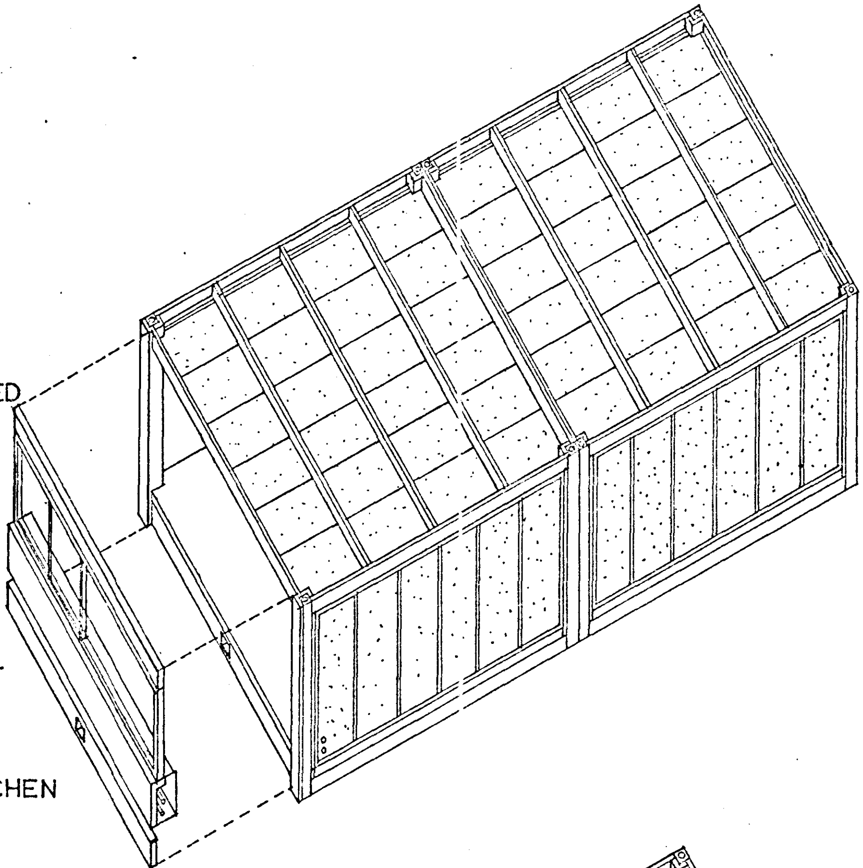
GYPSUM FLOOR PLANKS SET
AND WELDED TO OPEN
WEB BAR JOISTS
LAYERS OF MINERAL FIBRE
SOUND DEADENING BOARD
AND MASTICAL UNDER LAYMENT
COMPOUND LAID OVER FLOOR PLANKS
SIDE AND INTERIOR PARTITION
FRAMES MADE IN JIGS SECURED
TO ITS POSITION

SCALE $\frac{1}{8}'' = 1' - 0''$

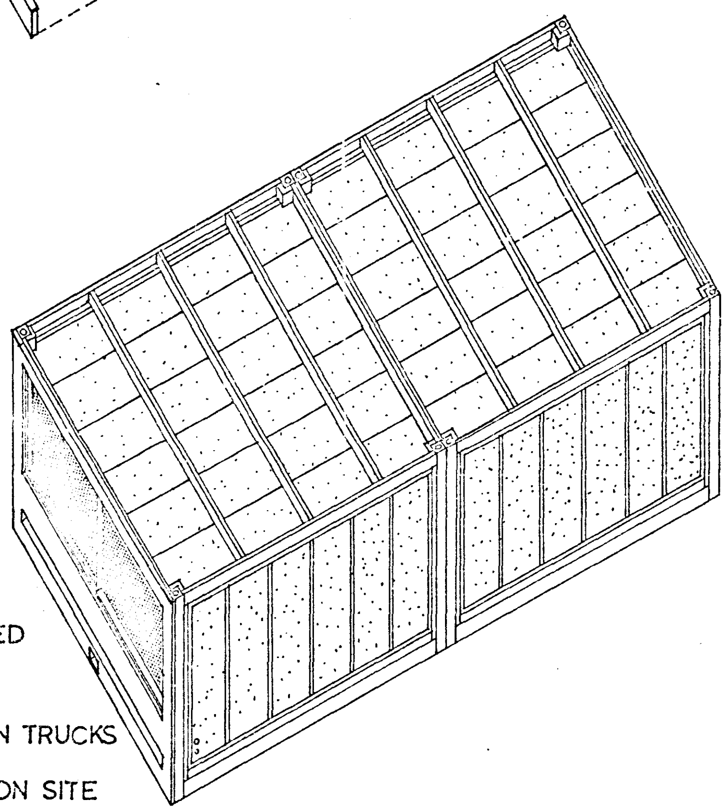
UNIT CONSTRUCTION

FIG. 7

WIRING PIPING INSTALLED
GYPSUM WALL PANELS
AND
INSULATION FIXED
END WINDOW FRAME
AND HEATING ELEMENT
INSTALLED
BATH ROOM AND KITCHEN
FIXTURES INSTALLED



MOVE TO FINISHING SHOP
APPLY FINISHED FLOOR AND
PAINTS TO WALL AND CEILING
PANEL
GLAZING AND WATER FROOFING
OPENINGS TEMPORARILY BRACED
AND THE WHOLE UNIT PROTECTED
WITH POLYETHYLENE
THE UNIT STORED OR LOADED ON TRUCKS
FOR TRANSPORT TO CONSTRUCTION SITE



SCALE $\frac{1}{8}''$ = 1' - 0''　　UNIT CONSTRUCTION

STANDARD MODULAR UNIT PLANS (Figs. 8 - 24)

TYPICAL KITCHEN UNIT PLANS (Fig. 25)

TYPICAL BATHROOM UNIT PLANS (Fig. 26)

TYPICAL DOOR AND CLOSET UNITS (Fig. 27)

The numbers 1 - 7 represent the functions of the spaces:

1 - living and dining

2 - living and kitchen; living, dining and kitchen

3 - bedroom and dressing room; bedroom and study; bedroom and stairwell

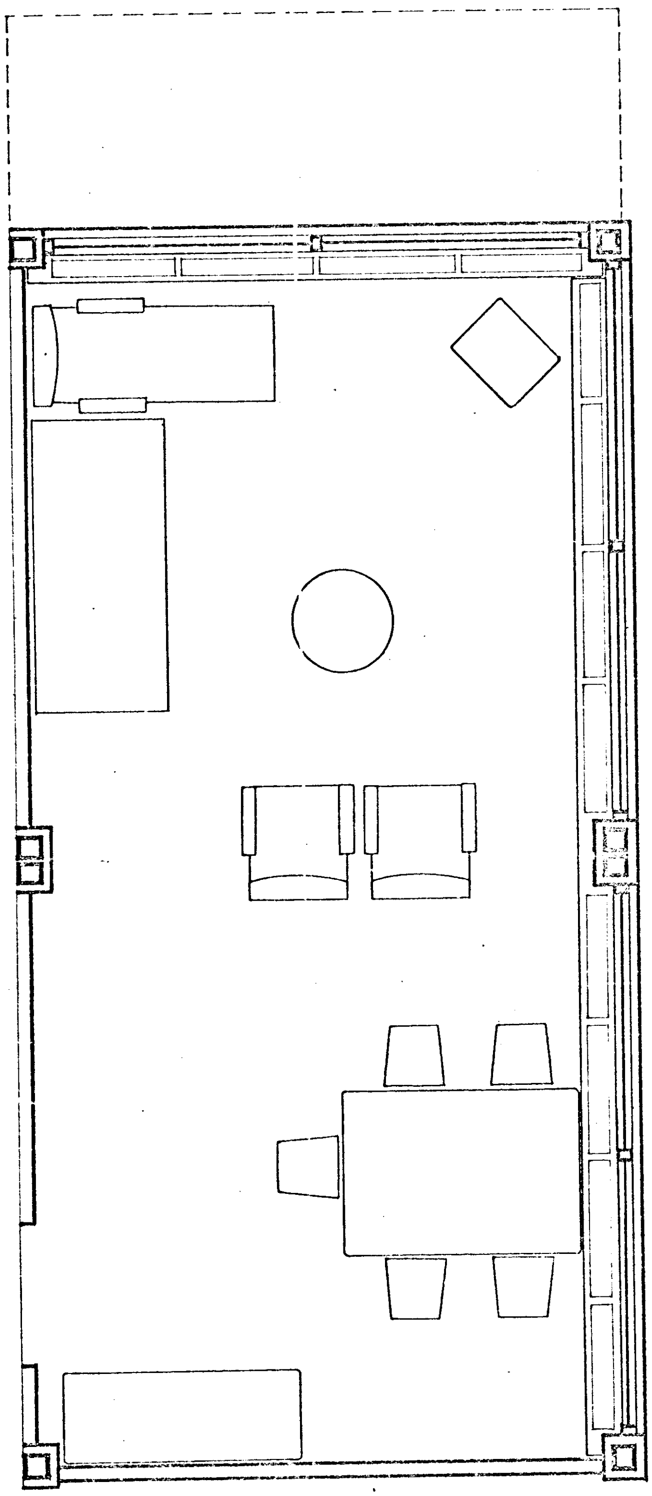
4 - bedroom and kitchen

5 - bedroom and bathroom(s)

6 - living, bedroom, kitchen and dining

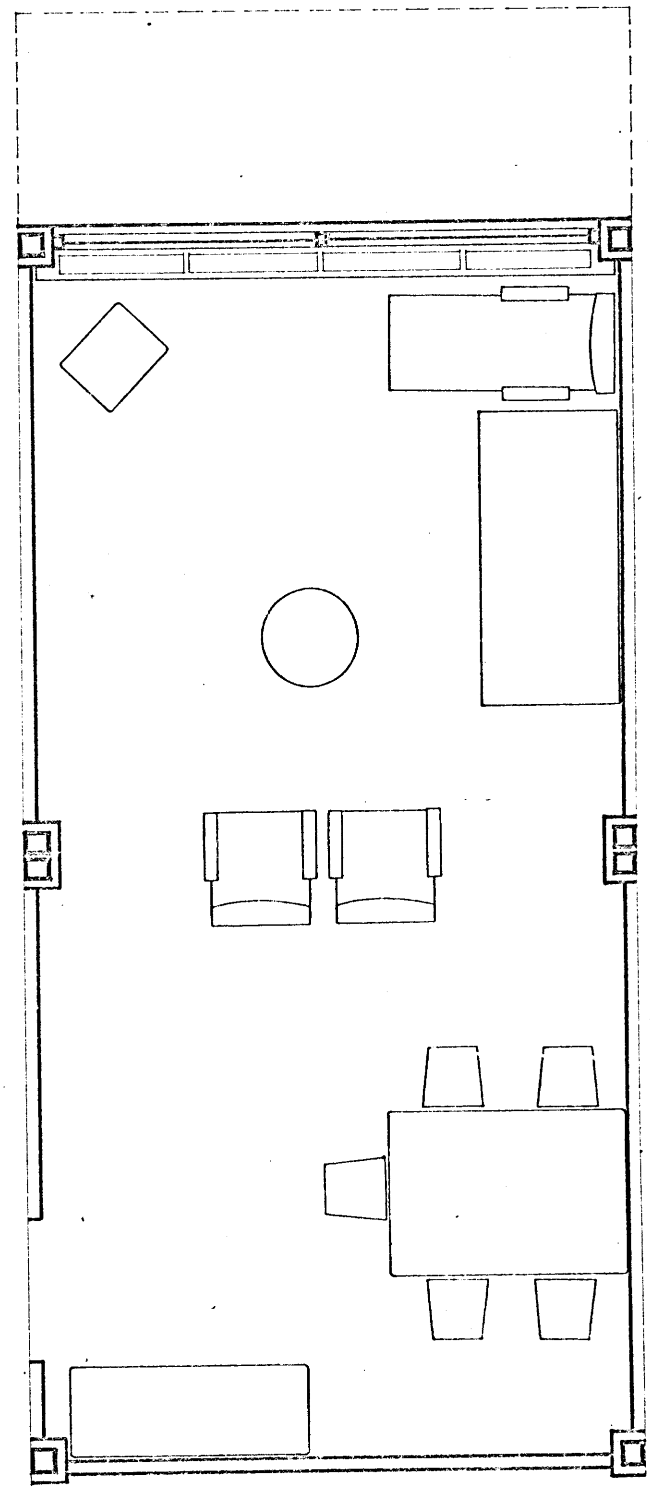
7 - bedroom; dining room

The alphabets A to T represent the various typical dwelling unit plans (efficiency, one-bedroom to four-bedroom).



LIVING DINING

1 $H_2$ $H_3$ $L_1$ $L_2$ $Q_1$ $Q_2$

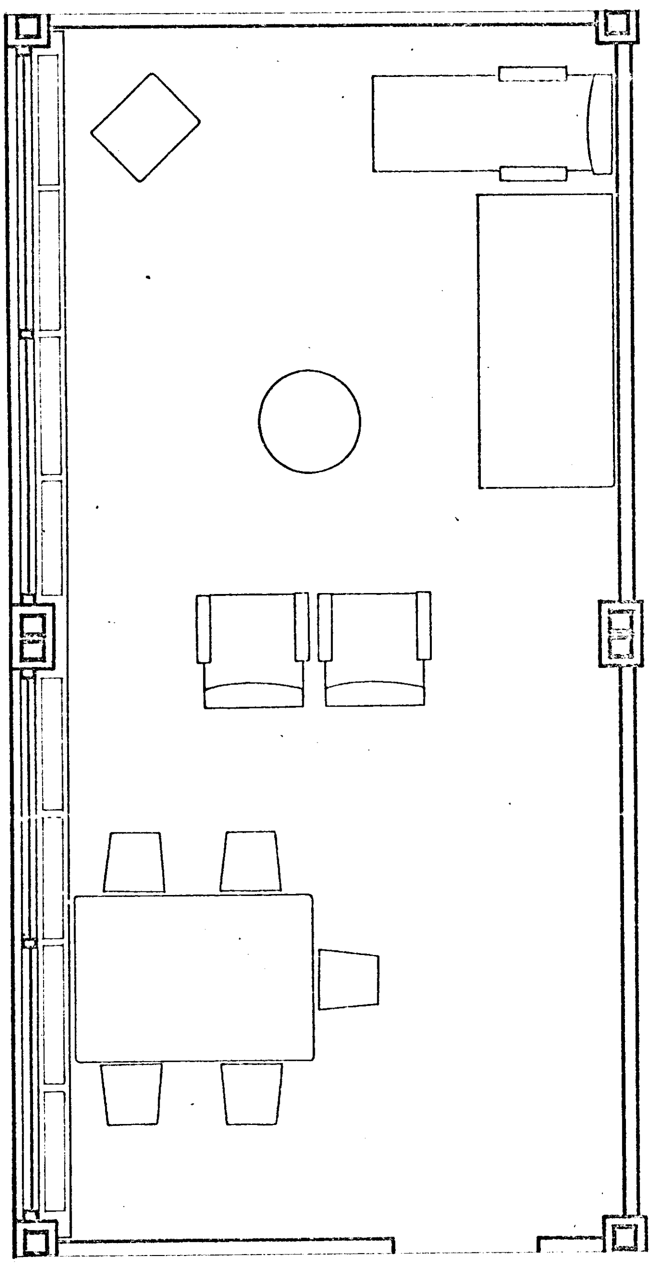


LIVING DINING

1 H $H_1$ L Q

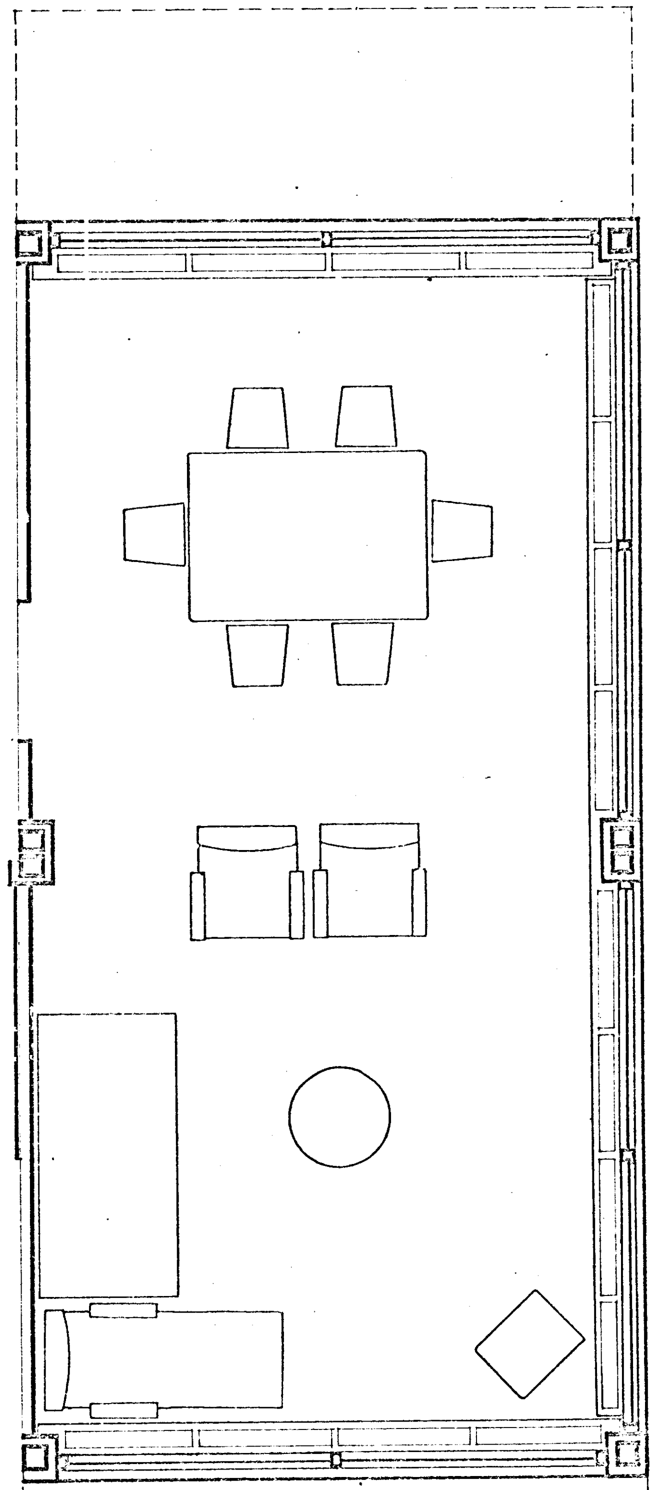
SCALE $\frac{1}{4}''$ = 1'-0" STANDARD MODULAR UNIT PLANS

FIG. 9



LIVING DINING

1 I M R

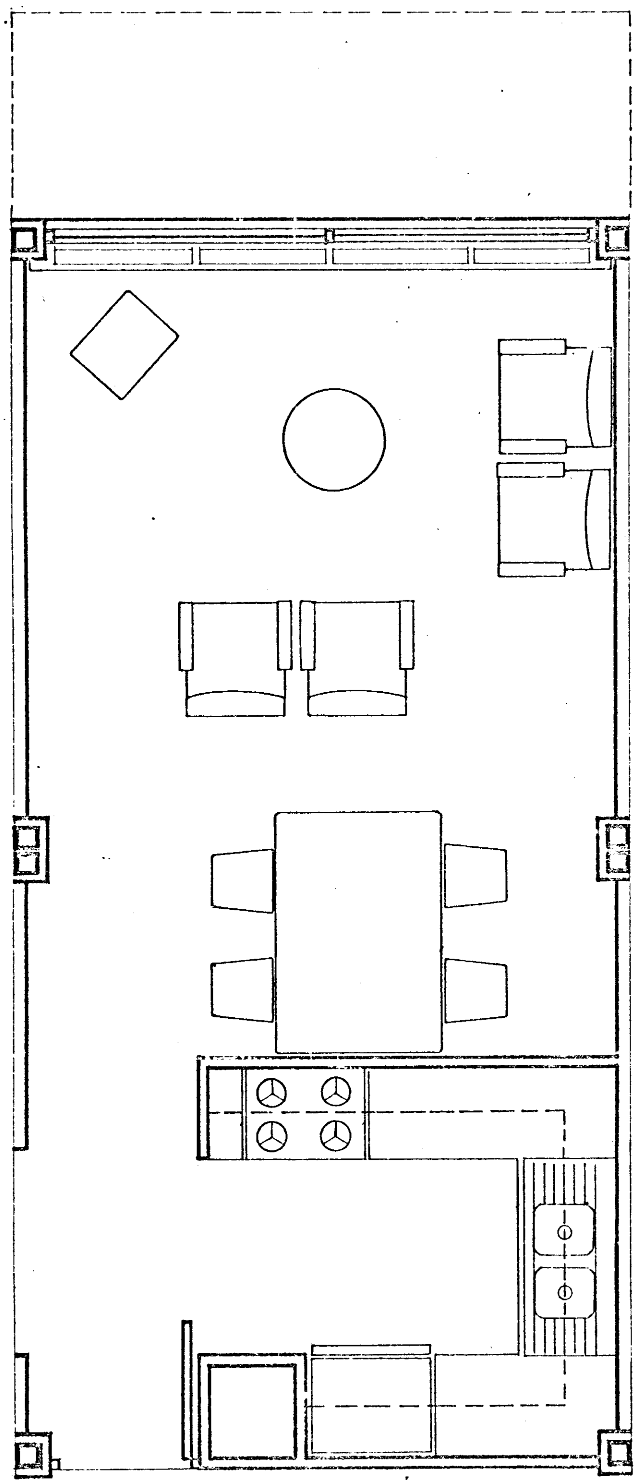


LIVING DINING

1 J N S

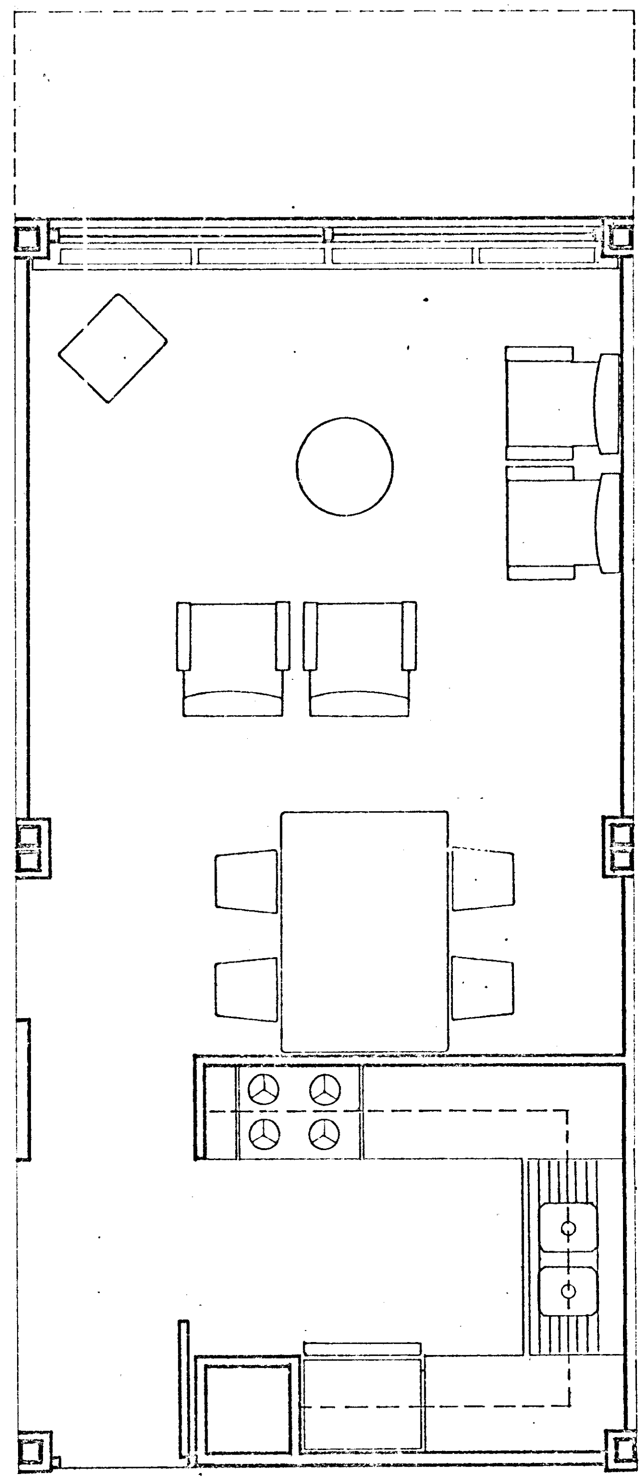
SCALE $\frac{1}{4}''$ = $1'-0''$ STANDARD MODULAR UNIT PLANS

FIG. 10



LIVING DINING KITCHEN

2 C

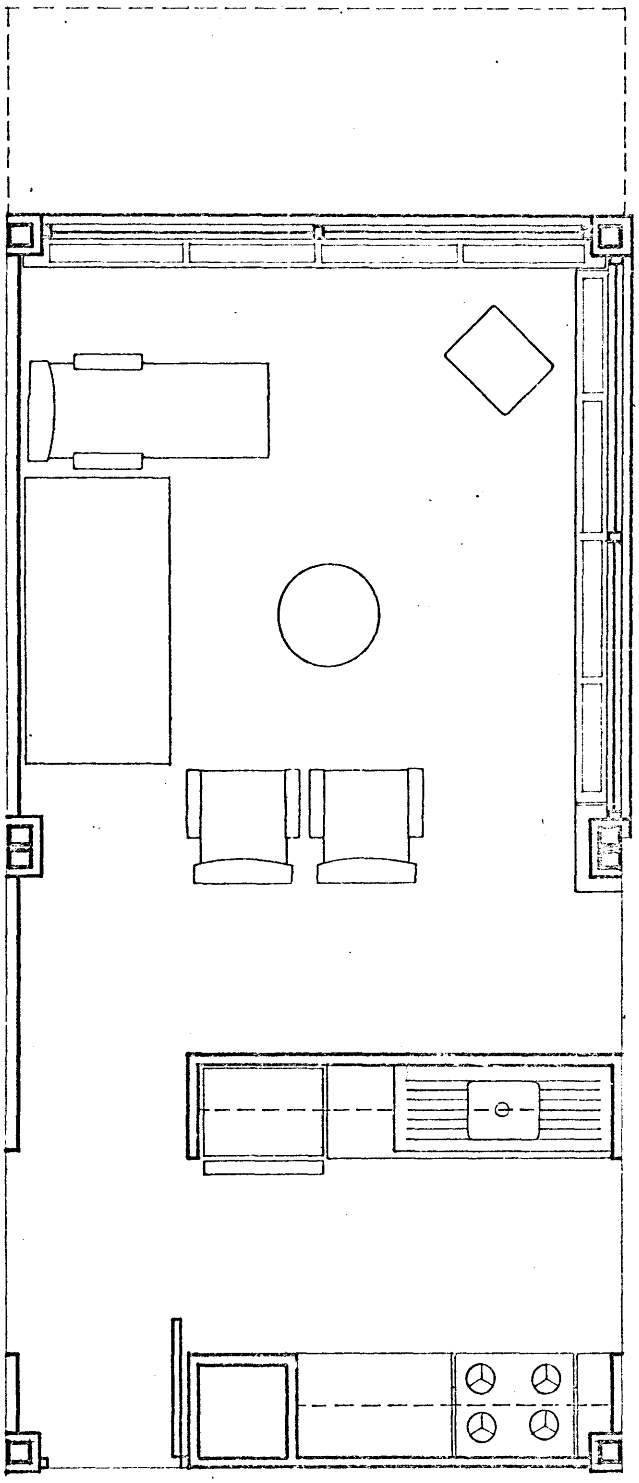


LIVING DINING KITCHEN

2 B O

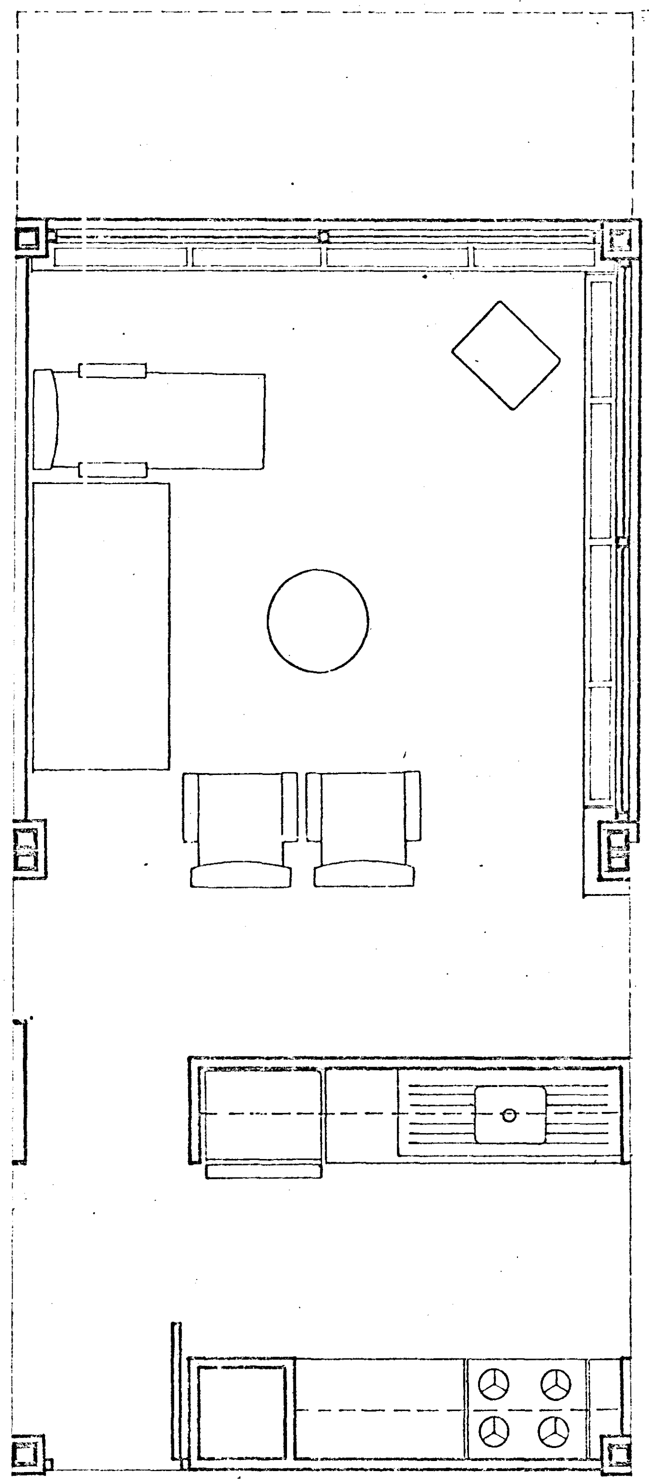
SCALE $\frac{1}{4}''$ = 1' - 0" STANDARD MODULAR UNIT PLANS

FIG.11



LIVING KITCHEN

2 F

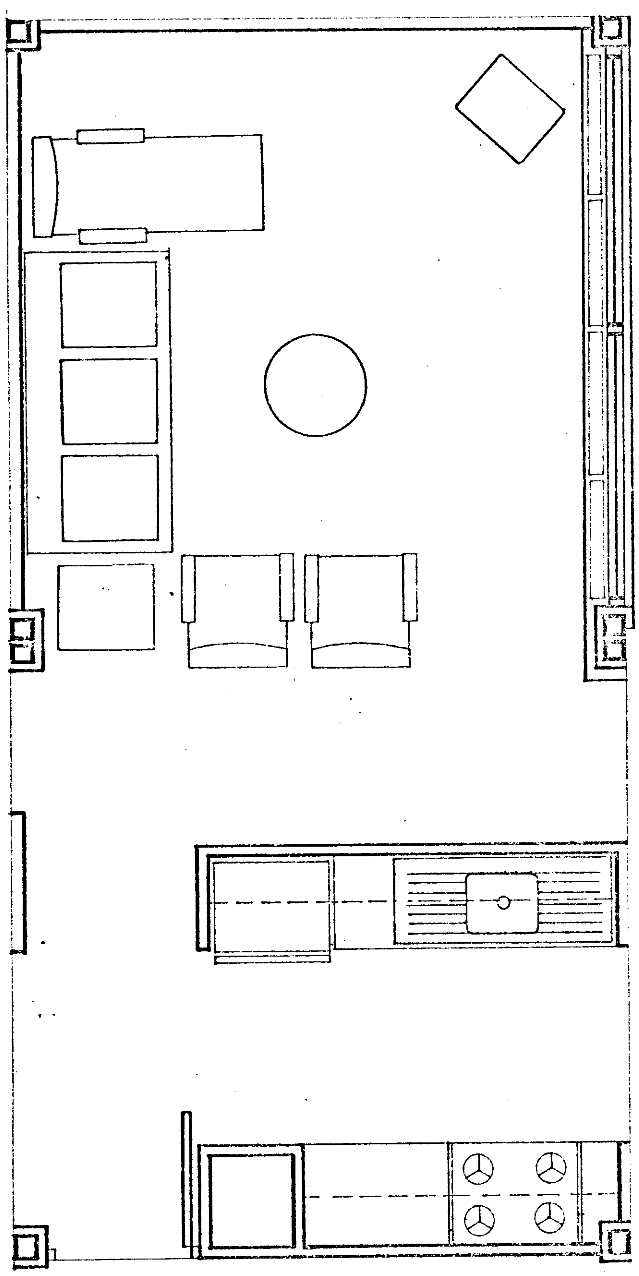


LIVING KITCHEN

2 E K P

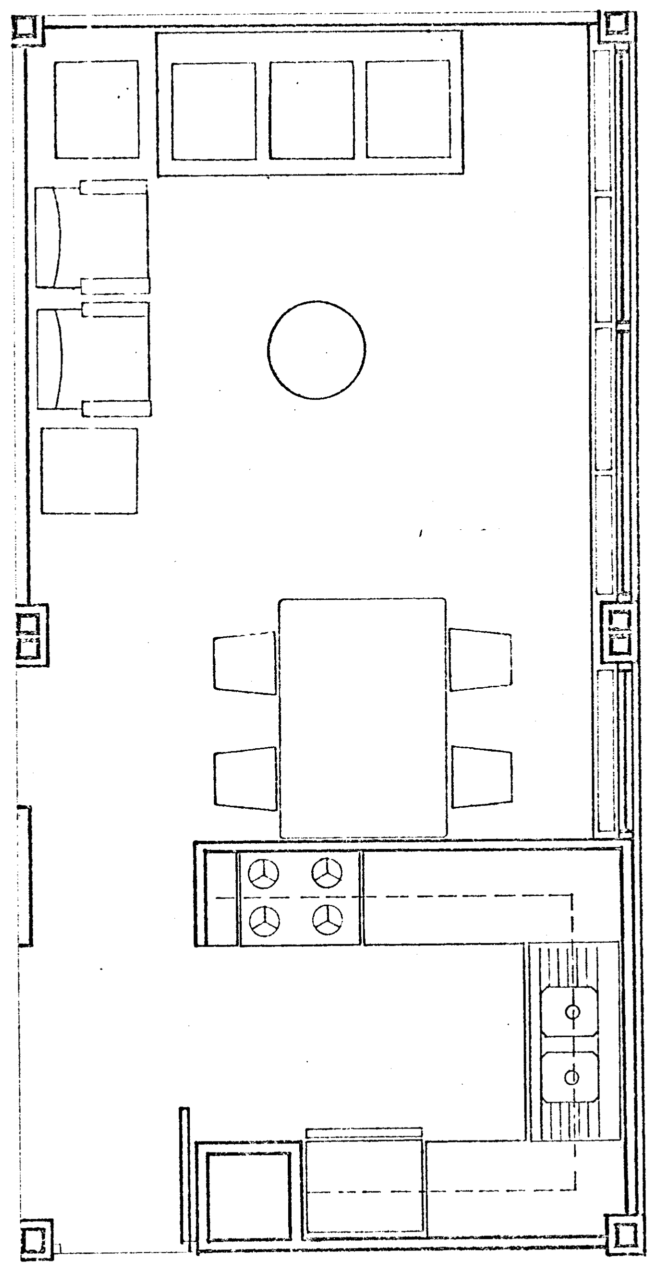
SCALE $\frac{1}{4}''$ = 1 - 0'' STANDARD MODULAR UNIT PLANS

FIG.12



LIVING KITCHEN

2 K

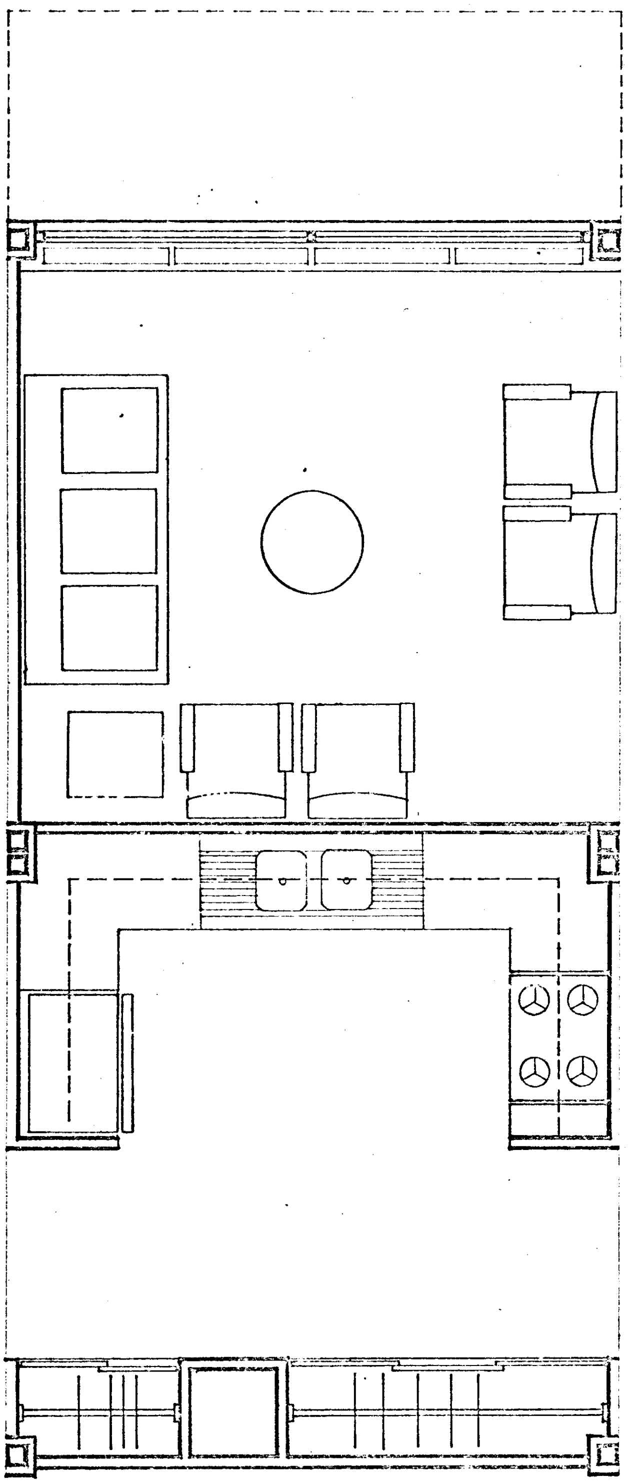


LIVING DINING KITCHEN

2 D G1

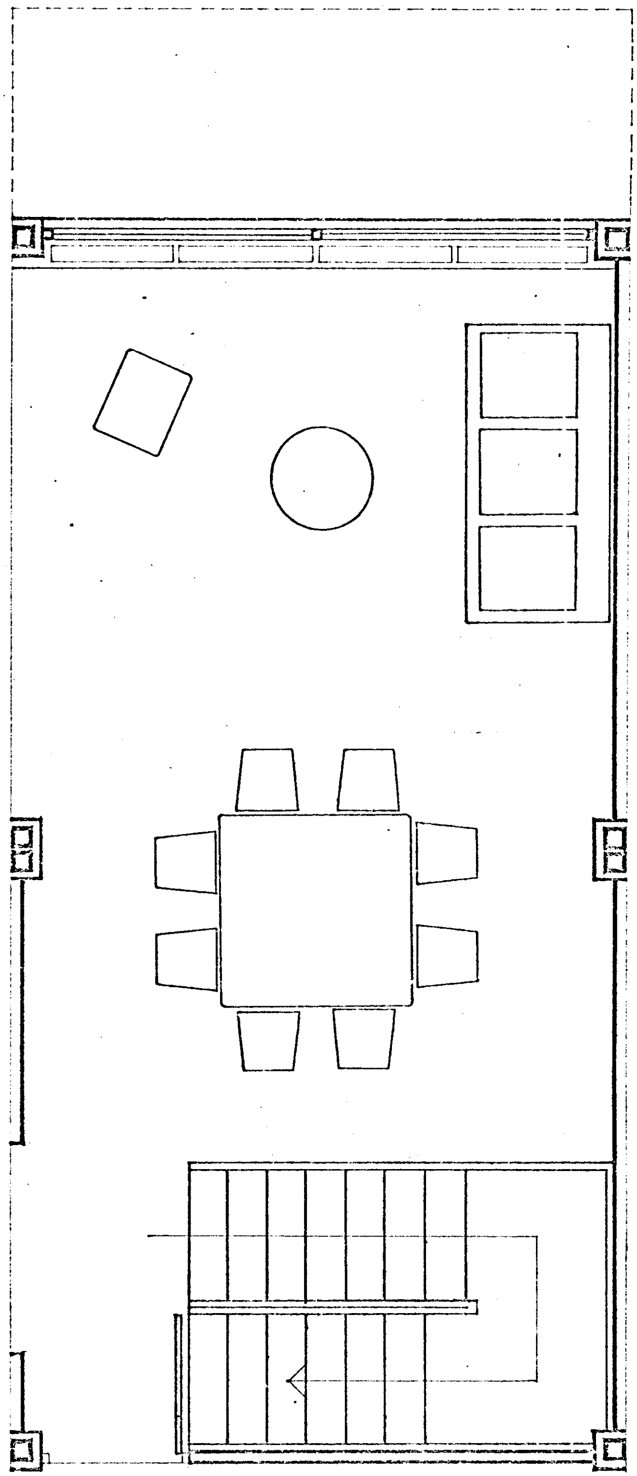
SCALE $\frac{1}{4}$" = 1'- 0" STANDARD MODULAR UNIT PLANS

FIG. 13



LIVING KITCHEN

2 $T_2$ $T_3$

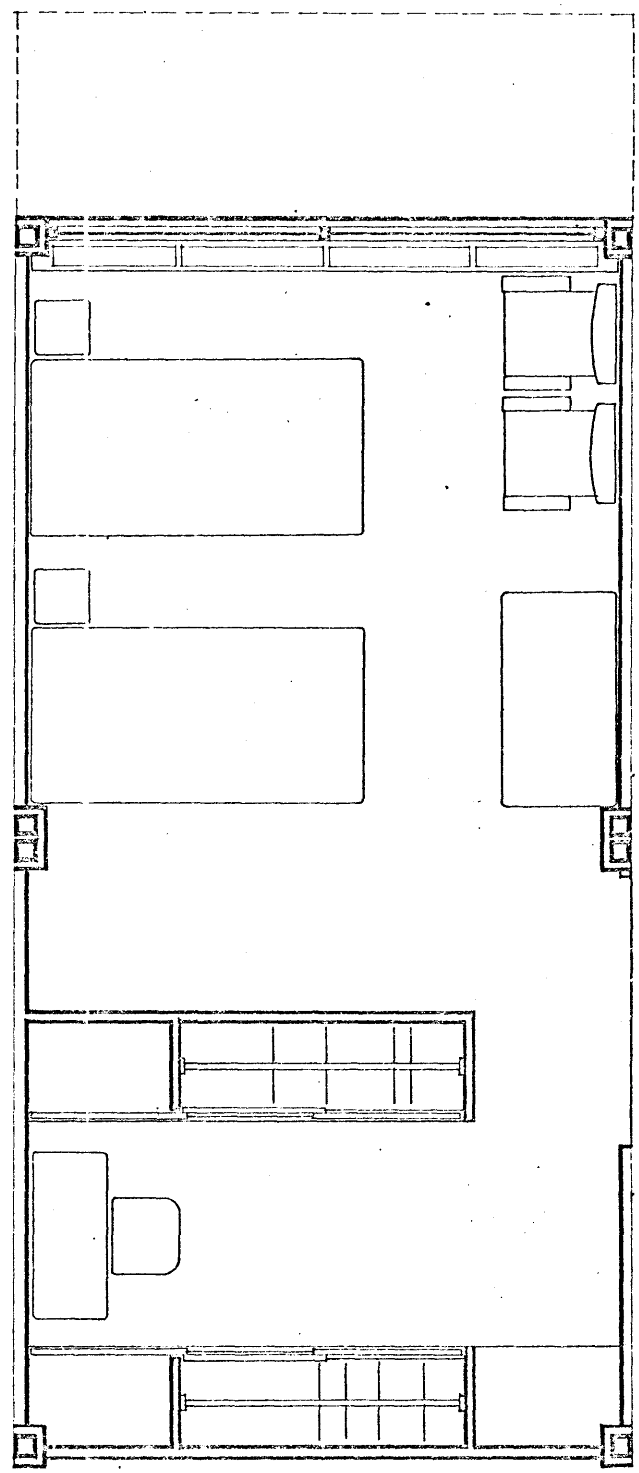


DINING STAIR

3 $T_2$ $T_3$

SCALE $\frac{1}{4}'' = 1' - 0''$ STANDARD MODULAR UNIT PLANS

FIG. 14

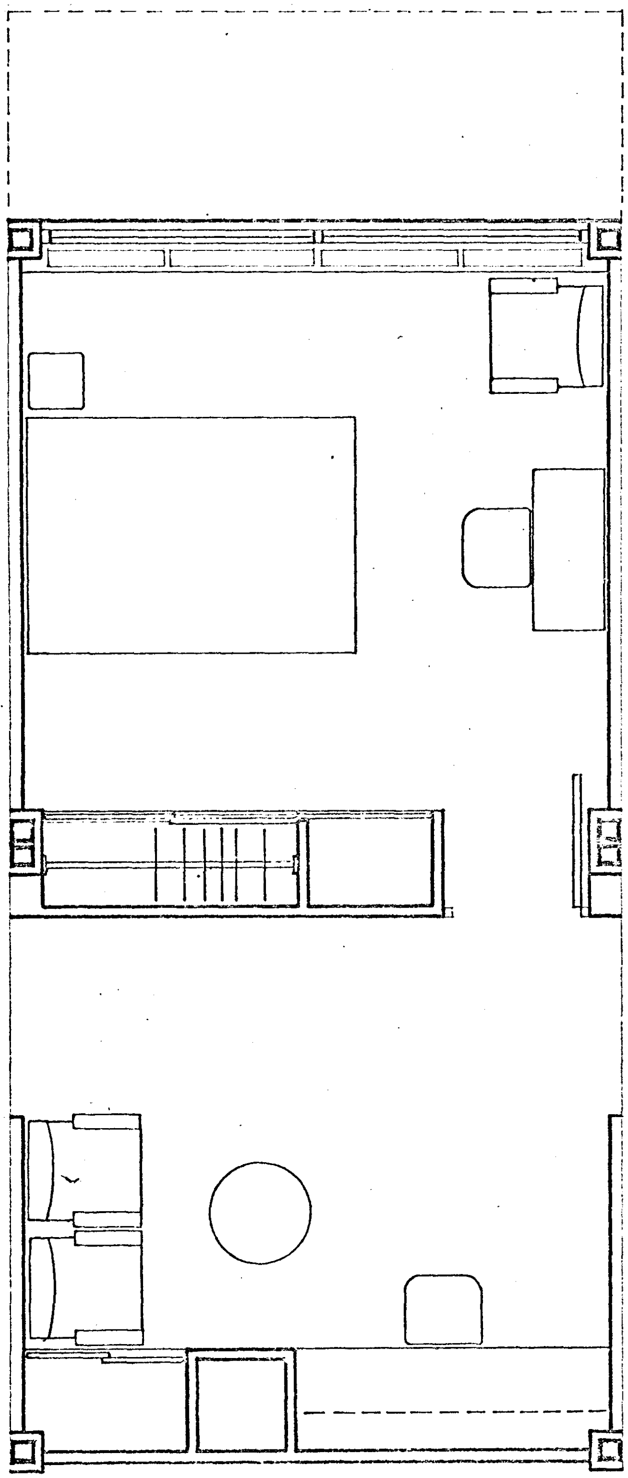


BEDROOM DRESSING ROOM

3 O P Q $Q_1$ $Q_2$ R S

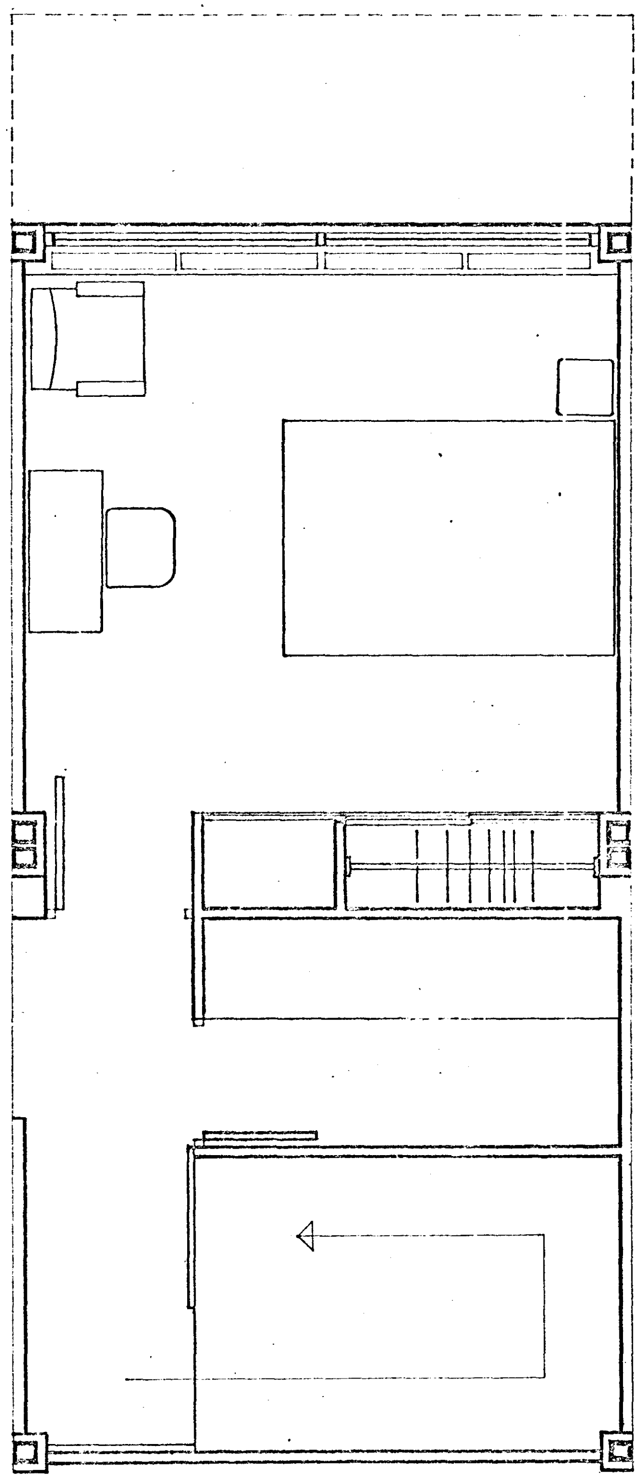
SCALE $\frac{1}{4}''$ = 1'-0" STANDARD MODULAR UNIT PLANS

FIG. 15



BEDROOM STUDY

3 $T_1$

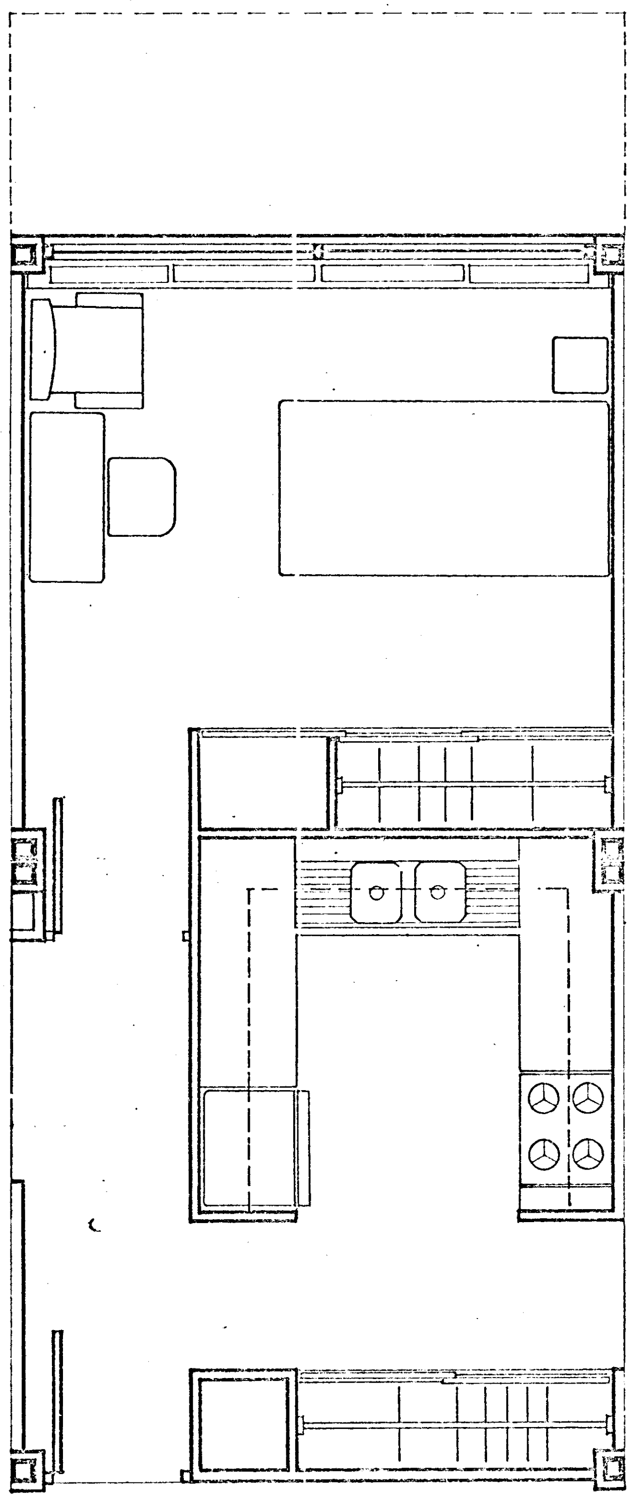


BEDROOM STAIR-WELL

3 $T_1$

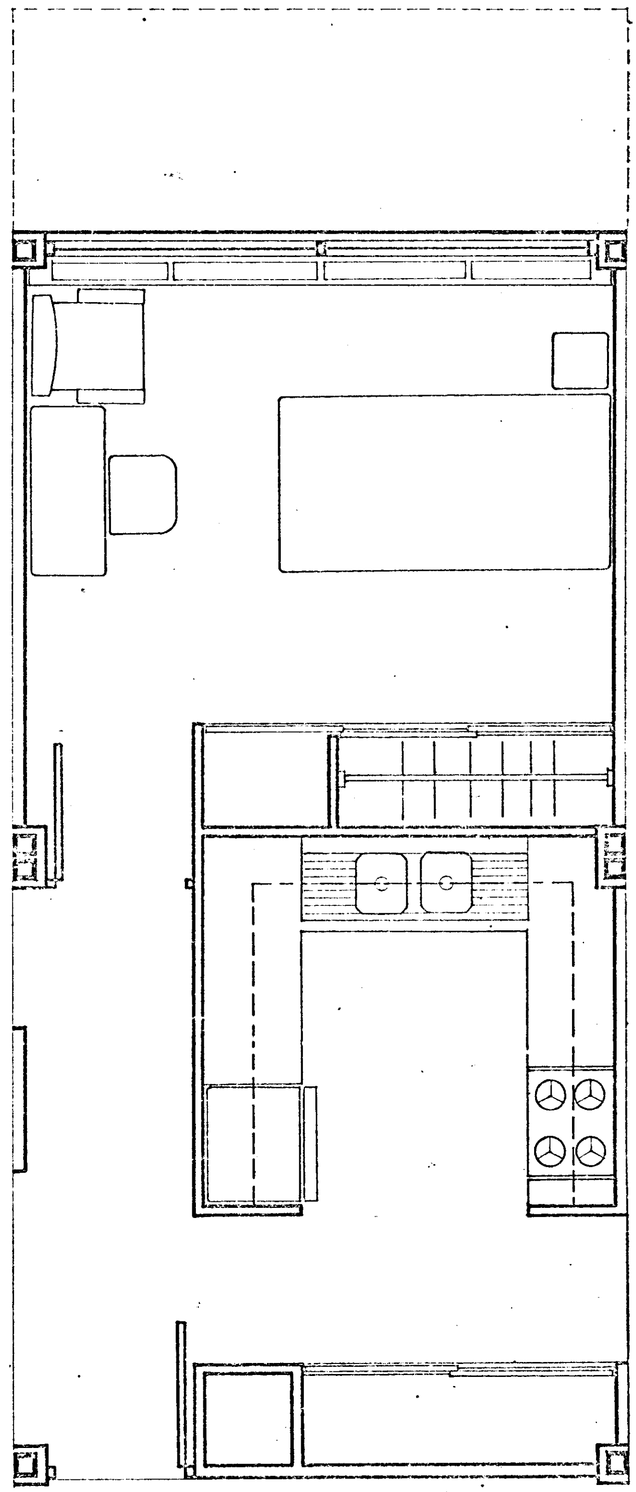
SCALE $\frac{1}{4}'' = 1' - 0''$ STANDARD MODULAR UNIT PLANS

FIG.16



BEDROOM KITCHEN

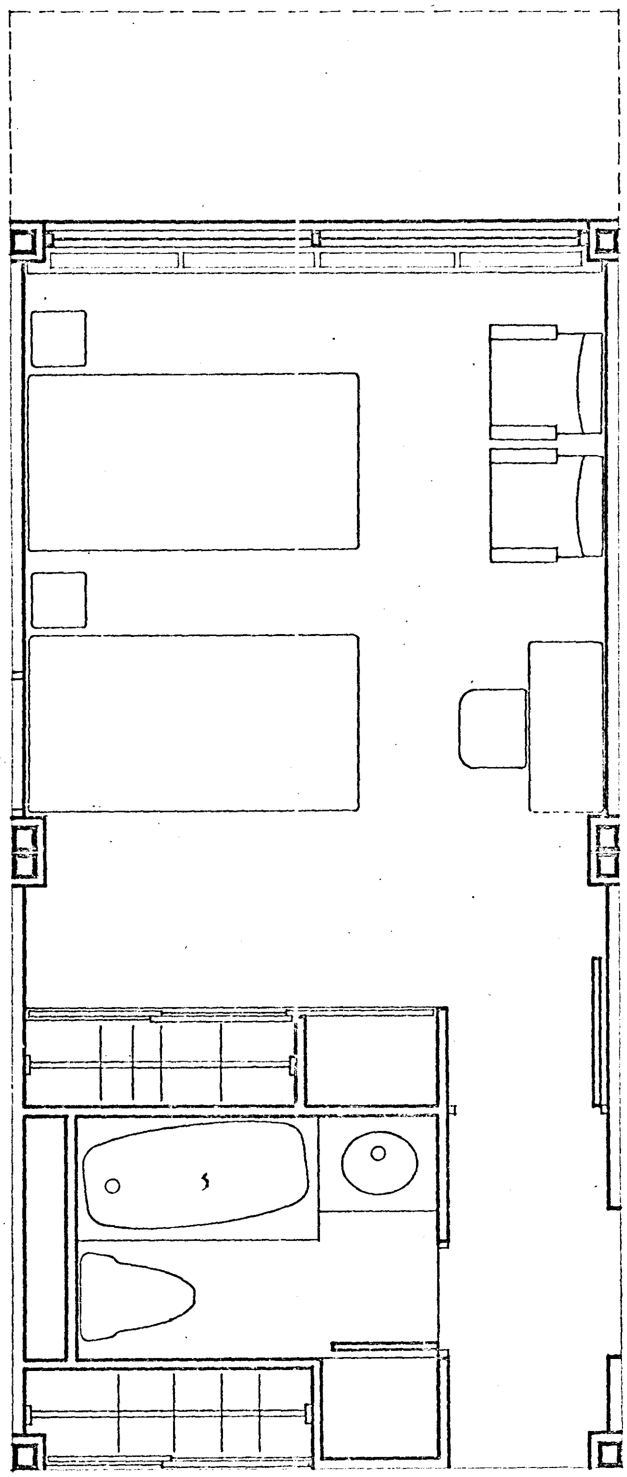
4 $L_1$ $L_2$ M N

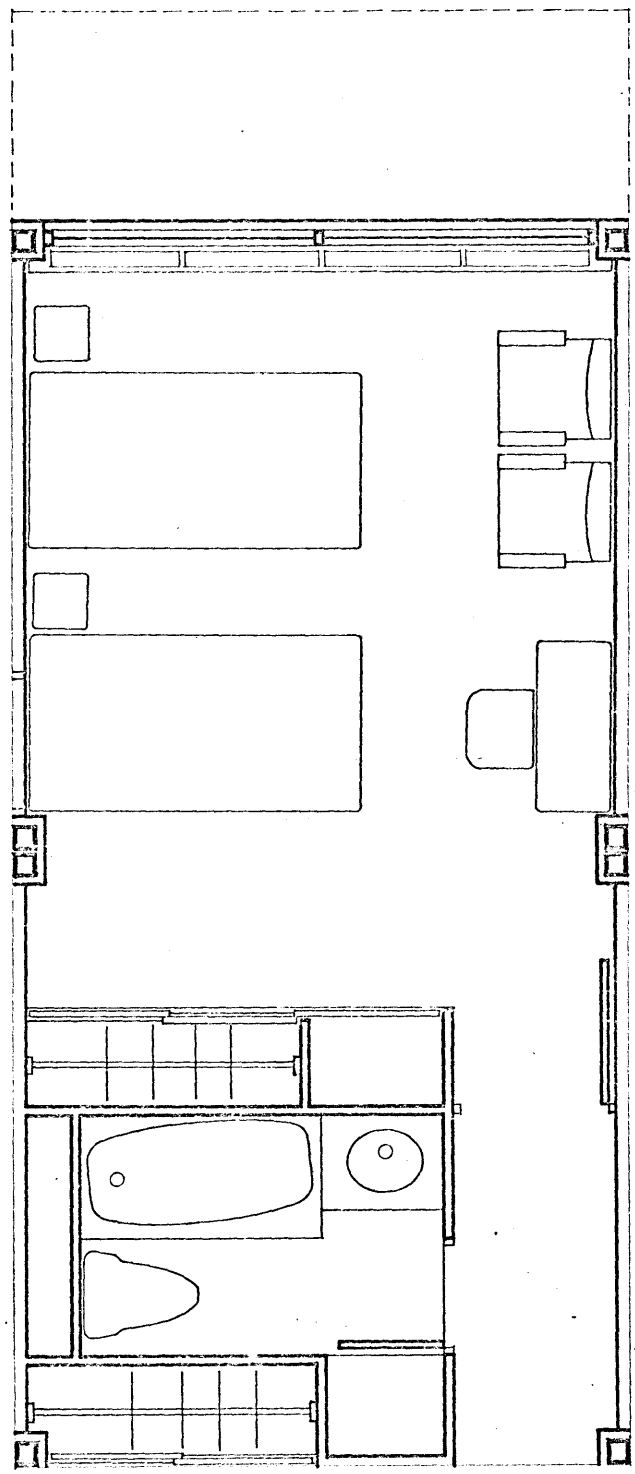


BEDROOM KITCHEN

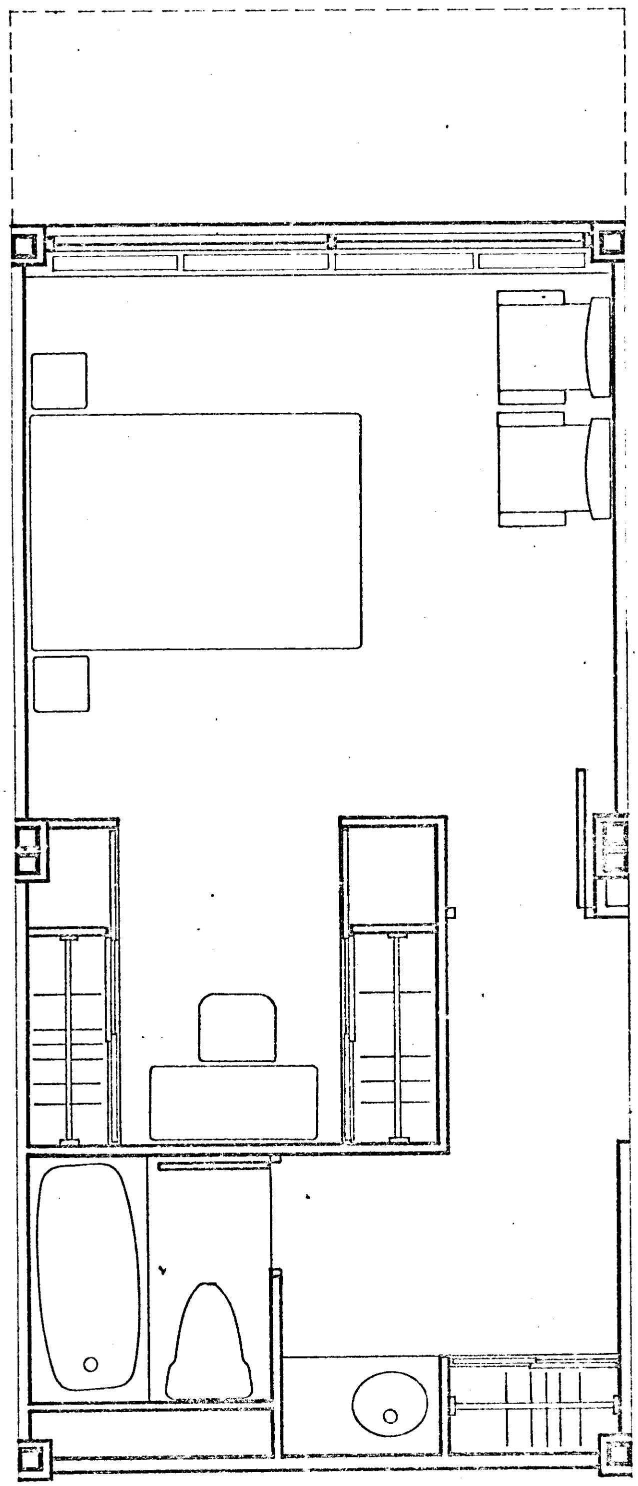
4 H $H_1$ $H_2$ $H_3$ I J Q $Q_1$ $Q_2$ S

SCALE $\frac{1}{4}''$ = 1' - 0'' STANDARD MODULAR UNIT PLANS



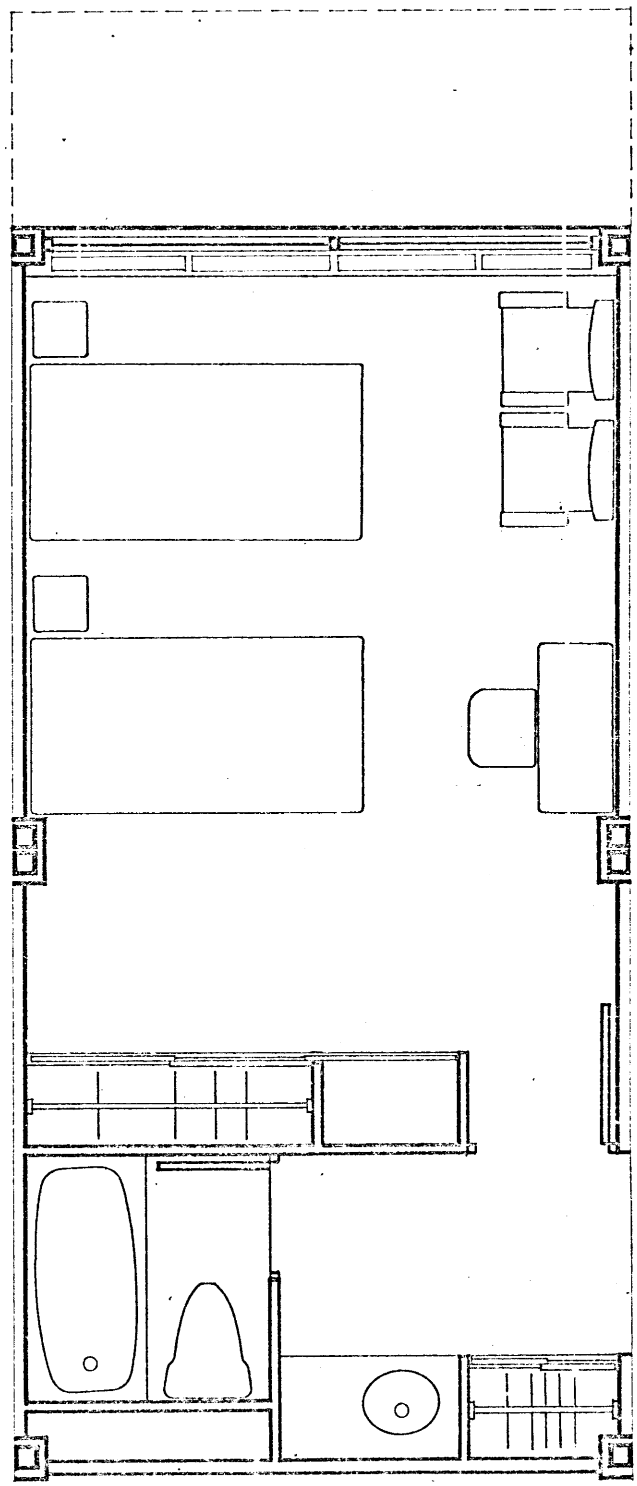




SCALE $\frac{1}{4}''$ = 1' - 0" STANDARD MODULAR UNIT PLANS



BEDROOM BATH

5 L $L_1$ $L_2$ M N $T_1$

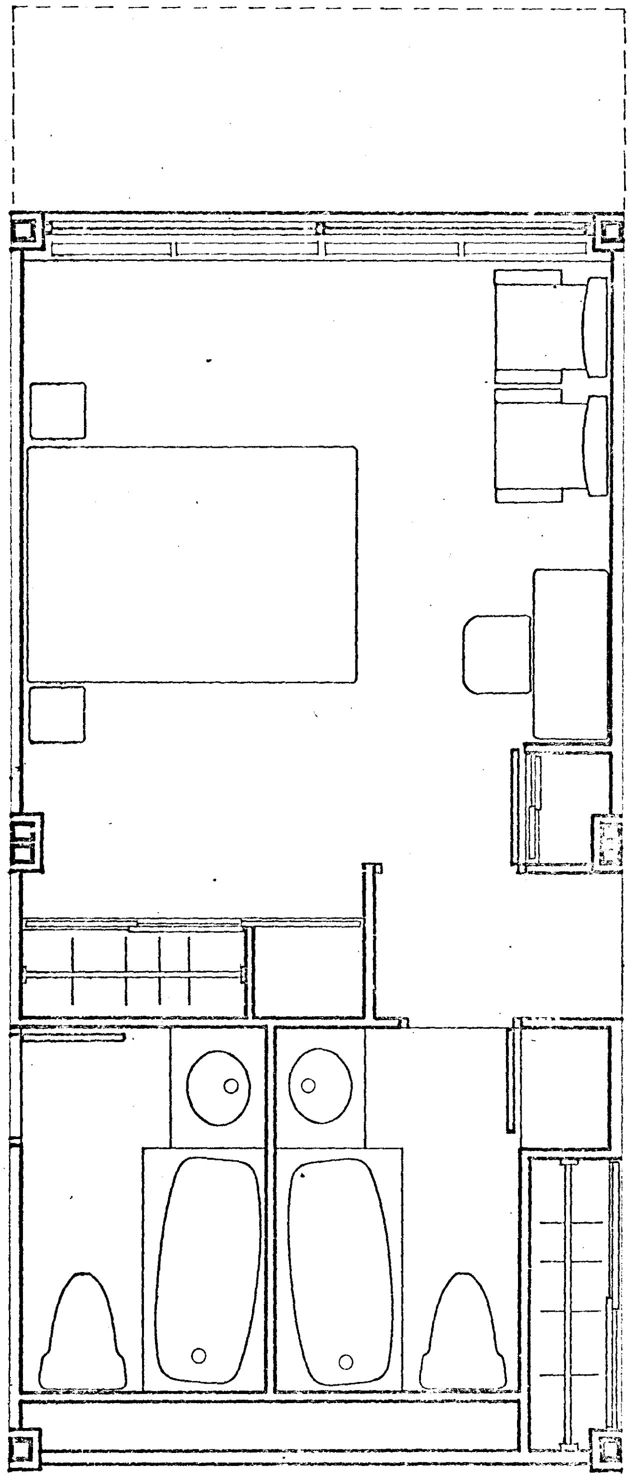


BEDROOM BATH

5 C F $T_2$ $T_3$

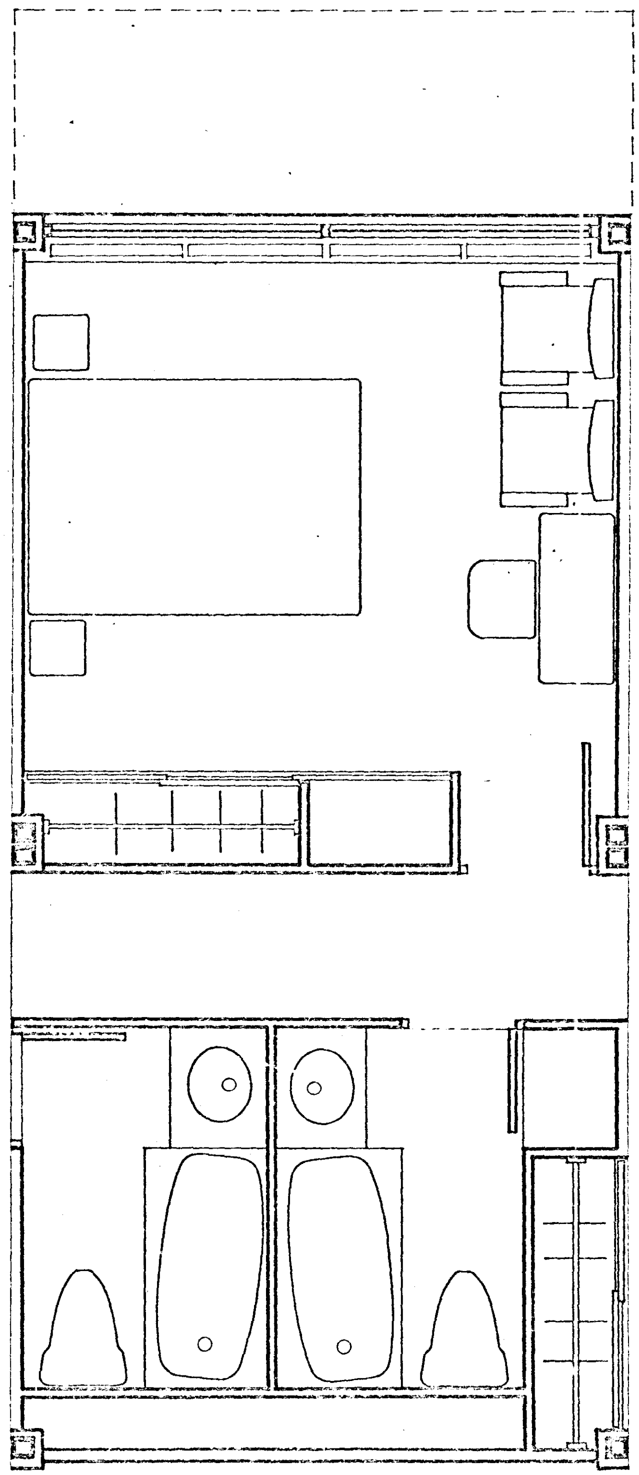
SCALE $\frac{1}{4}''$ = 1'- 0" STANDARD MODULAR UNIT PLANS

FIG.19



BEDROOM BATH

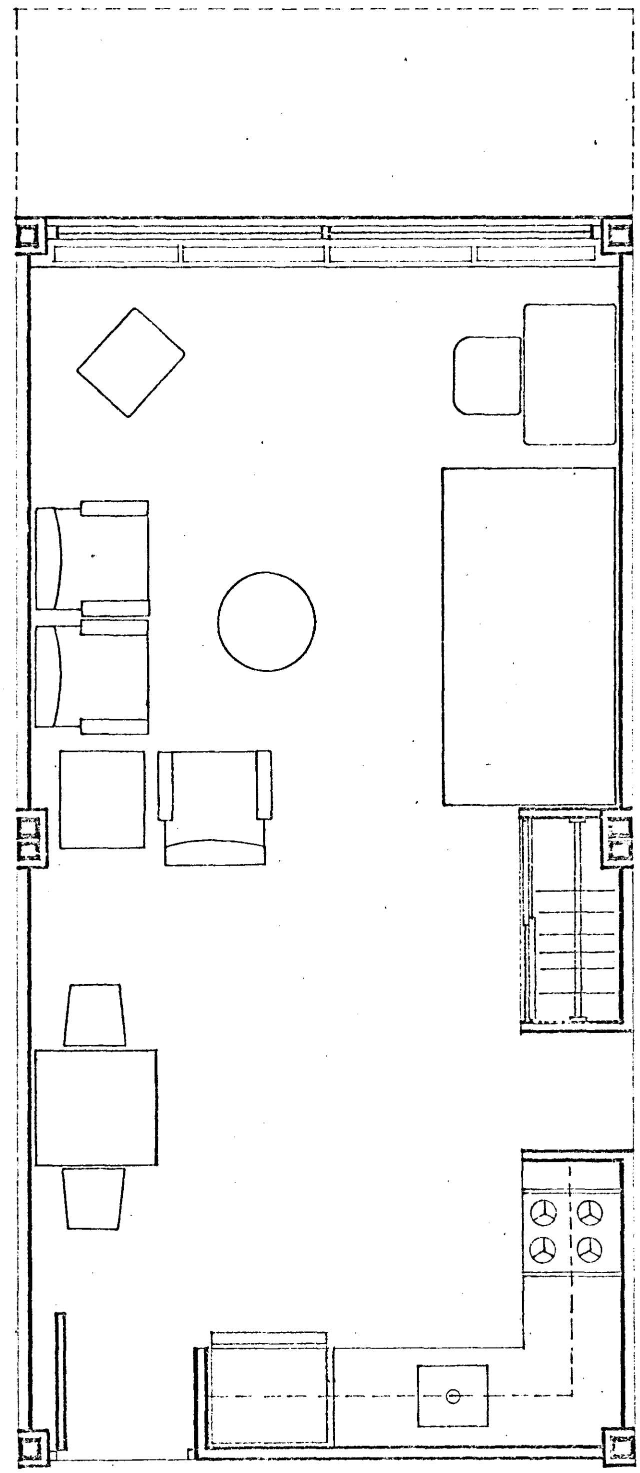
5 H $H_1$ $H_2$ $H_3$ I J



BEDROOM BATH

5 O P Q $Q_1$ $Q_2$ R S

SCALE $\frac{1}{4}''$ = 1'-0" STANDARD MODULAR UNIT PLANS

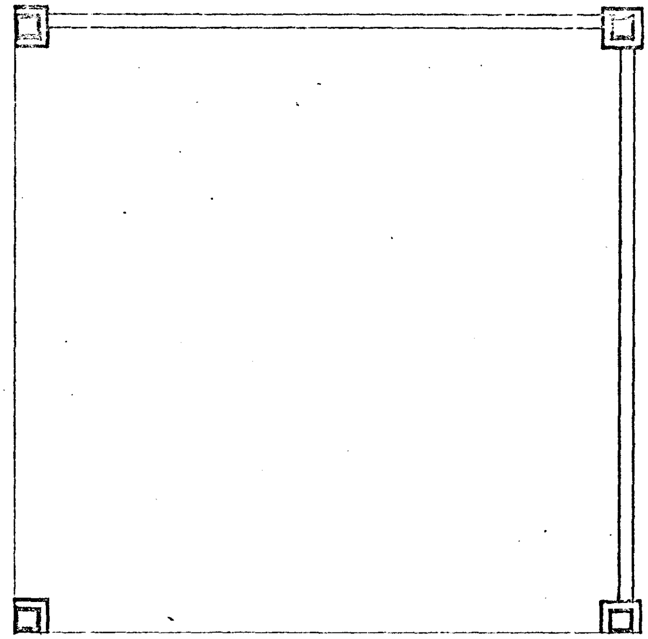


LIVING BEDROOM KITCHEN DINING

6 A

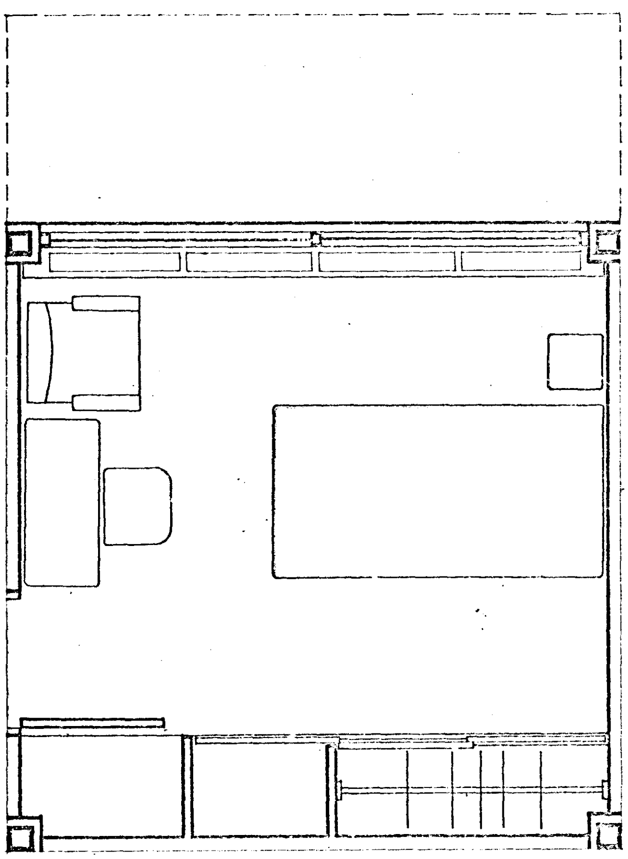
SCALE $\frac{1}{4}''$ = 1'-0" STANDARD MODULAR UNIT PLANS

FIG. 21



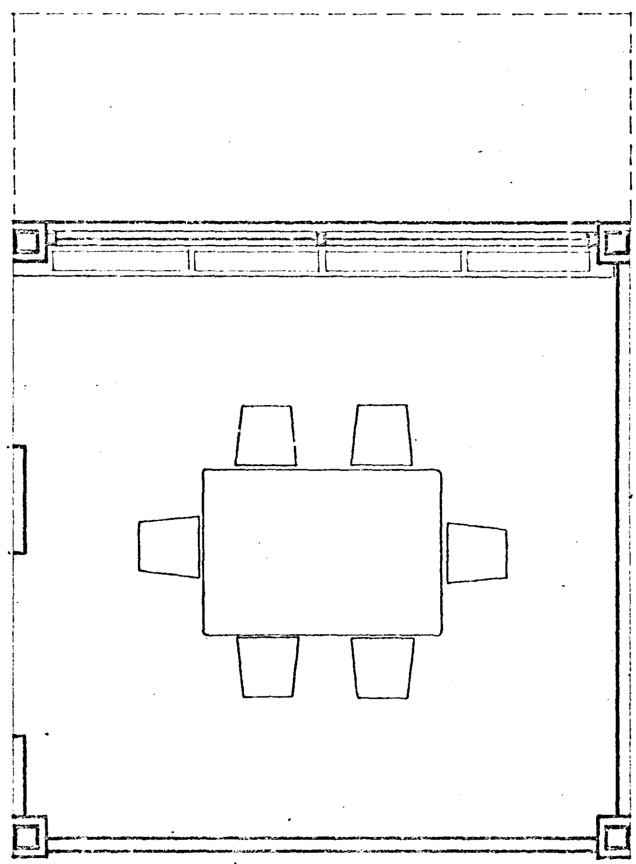
PATIO UNIT

7 E F



BEDROOM

7 G G1 K

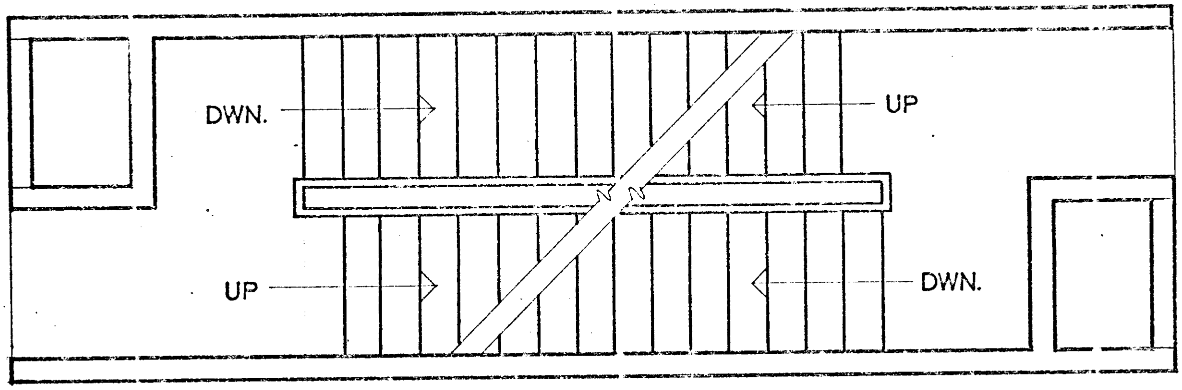


DINING ROOM

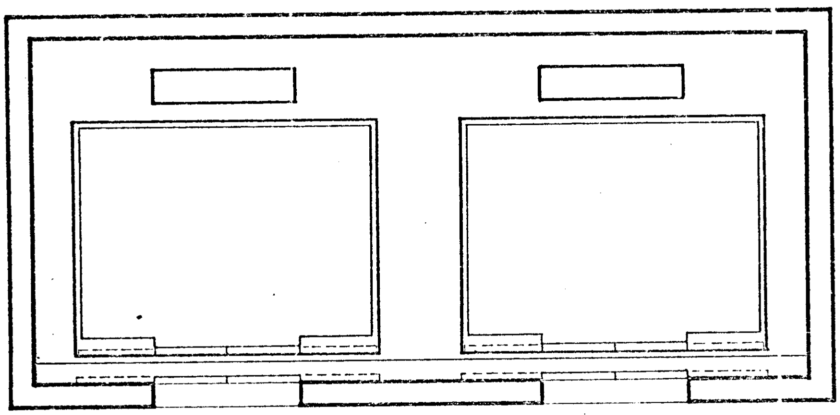
7 E F K P

SCALE 1/4" = 1'-0" STANDARD MODULAR UNIT PLANS

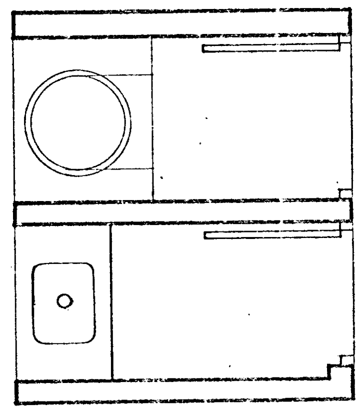
FIG.22



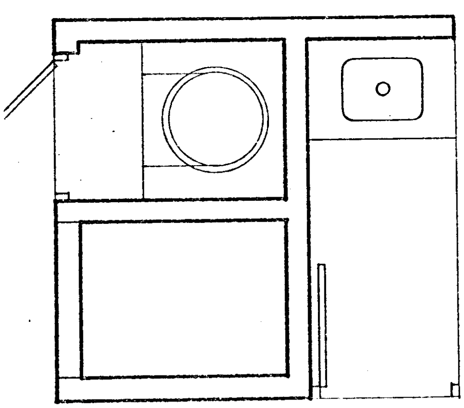

STAIR CASE UNIT



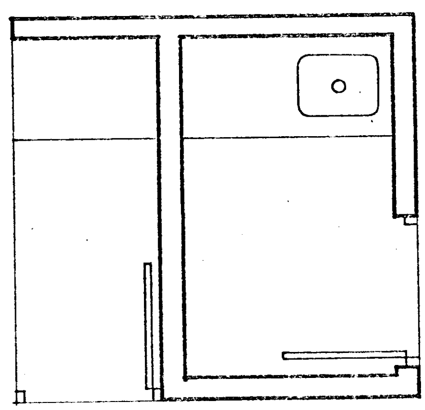
TWO ELEVATOR UNIT



JANITOR OR ELECTRIC CLOSET INCINERATOR UNIT



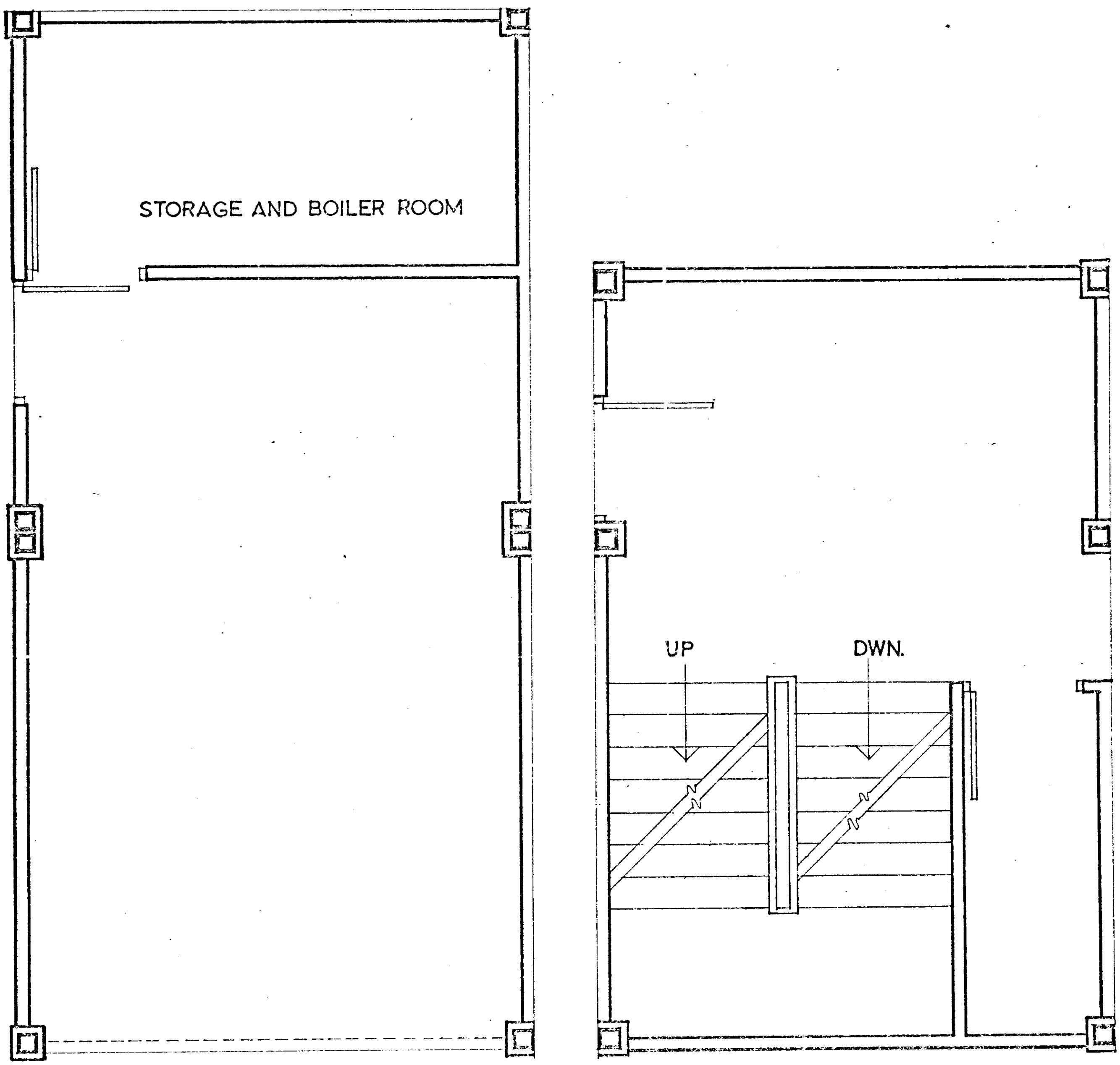
VENTILATING DUCT JANITOR INCINERATOR UNIT



ELECTRIC CLOSET JANITOR UNIT

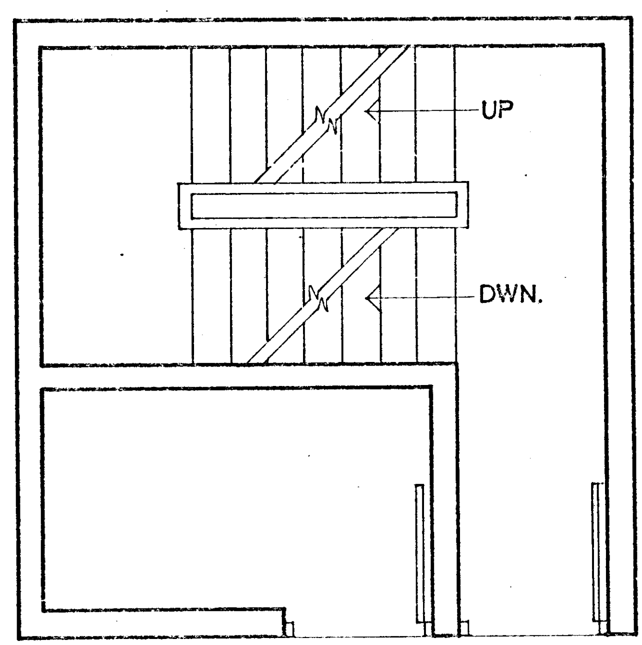
SCALE $\frac{1}{4}'' = 1' - 0''$ STANDARD MODULAR UNIT PLANS

FIG. 23



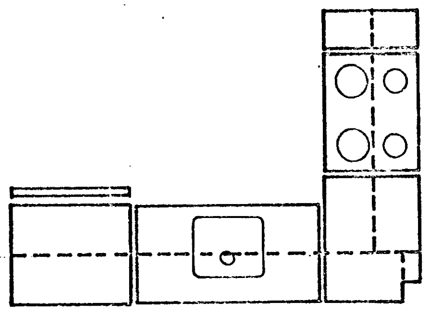

GARAGE UNIT STAIR CASE

SCALE 1/4" = 1'-0" STANDARD MODULAR UNIT PLANS

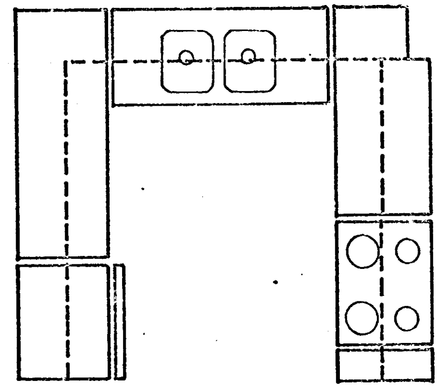



STAIR CASE

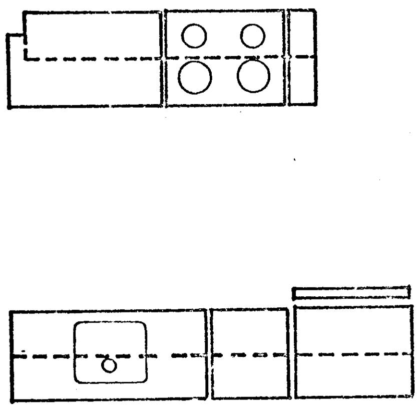
SCALE $\frac{1}{4}'' = 1' - 0''$ STANDARD MODULAR UNIT PLANS



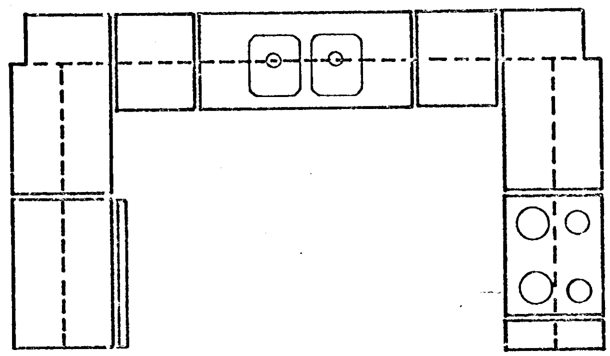
IN PLAN A



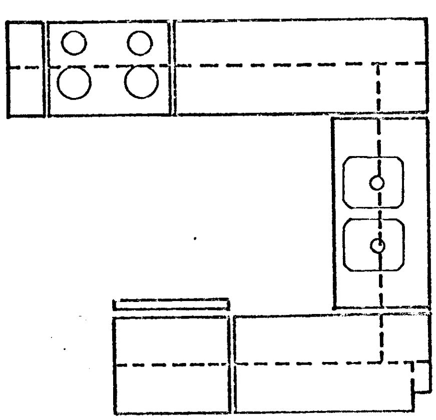
IN PLANS $L_1$ $L_2$ M N H $H_1$ $H_2$ $H_3$ I J Q $Q_2$ S



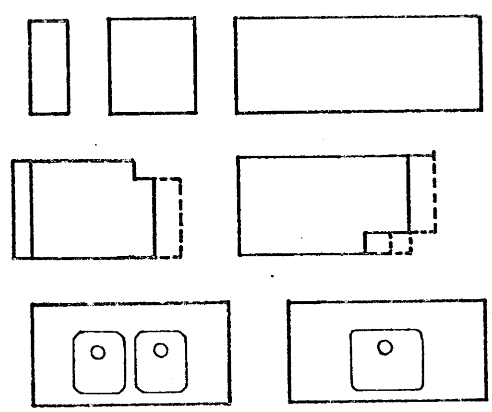
IN PLANS F E K P



IN PLANS $T_1$ $T_2$



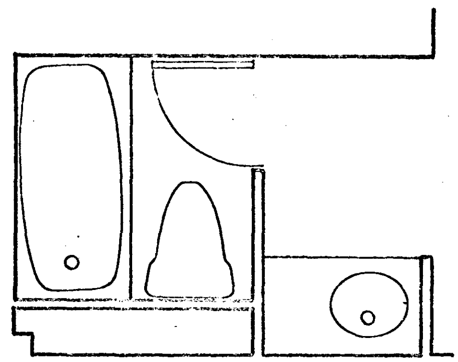
IN PLANS B D G O



KITCHEN FIXTURE COMPONENTS

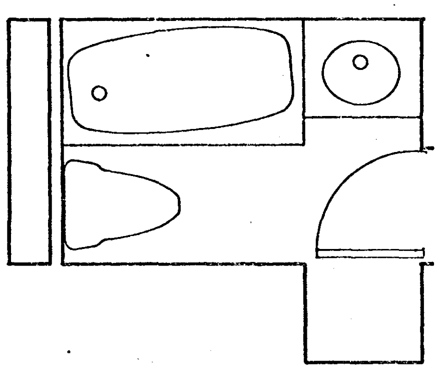
SCALE $\frac{1}{4}''$ = 1'-0"

# TYPICAL KITCHEN UNIT PLANS



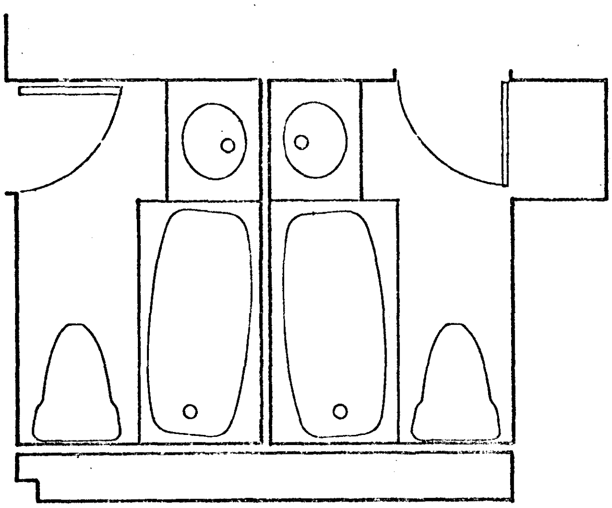
BATH ROOM UNIT IN DWELLING

C F L $L_1$ $L_2$ M N $T_1$ $T_2$ $T_3$



BATH ROOM UNIT IN DWELLING

UNITS G $G_1$ K D



BATH ROOM UNIT IN DWELLING

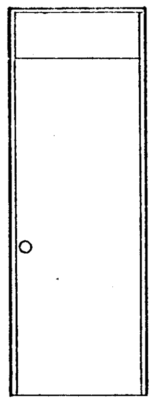
UNITS A B H $H_1$ $H_2$ $H_3$ I J O P

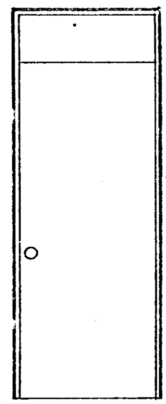
Q $Q_1$ $Q_2$ R S

SCALE $\frac{1}{4}'' = 1'-0''$ TYPICAL BATH ROOM UNIT PLANS

FIG.27

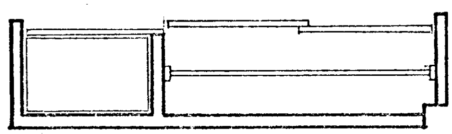
DOOR BATH; STORAGE



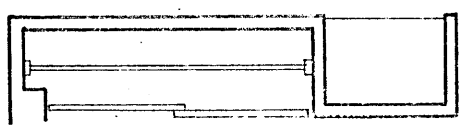


DOOR ENTERING TO DWELLING UNIT BEDROOM

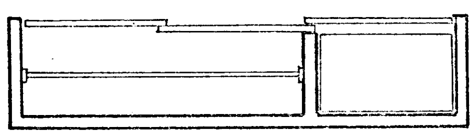
CLOSET IN DWELLING UNIT



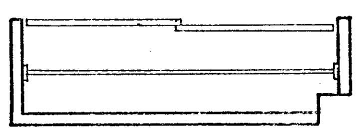
G G K L L M N H $H_1$ $H_2$ $H_3$ I J Q $Q_1$ $Q_2$ S $T_1$



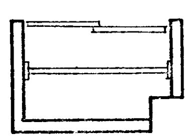
D G $G_1$ K H $H_1$ $H_2$ $H_3$ I J O P Q $Q_2$ R S



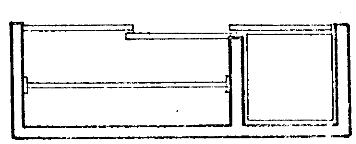
D G $G_1$ K O P Q $Q_1$ $Q_2$ R S $T_1$



$L_1$ $L_2$ M N H $H_1$ $H_2$ $H_3$ I J Q $Q_1$ $Q_2$ S



C F L $L_1$ $L_2$ M N $T_1$ $T_2$ $T_3$



H $H_1$ $H_2$ $H_3$ I J

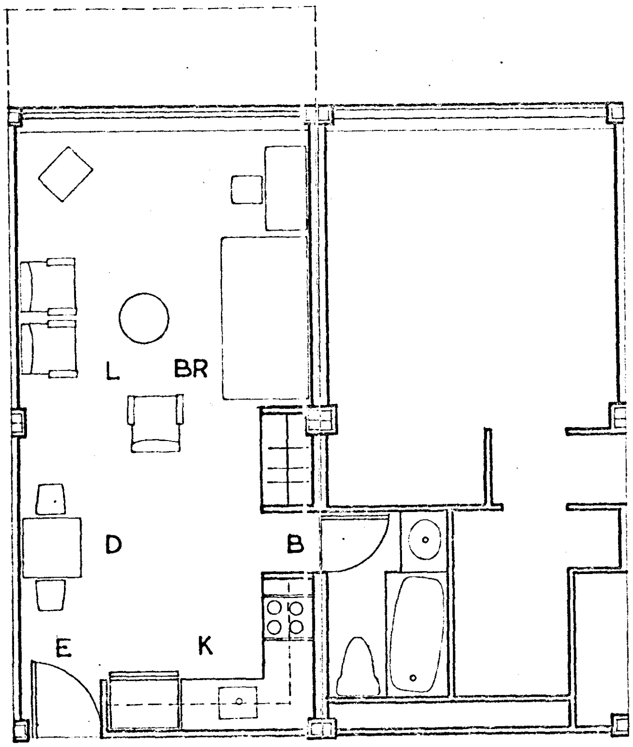
SCALE $\frac{1}{4}''$ = 1'-0" TYPICAL DOOR & CLOSET UNITS

TYPICAL DWELLING UNIT PLANS (Figs. 28 - 45)

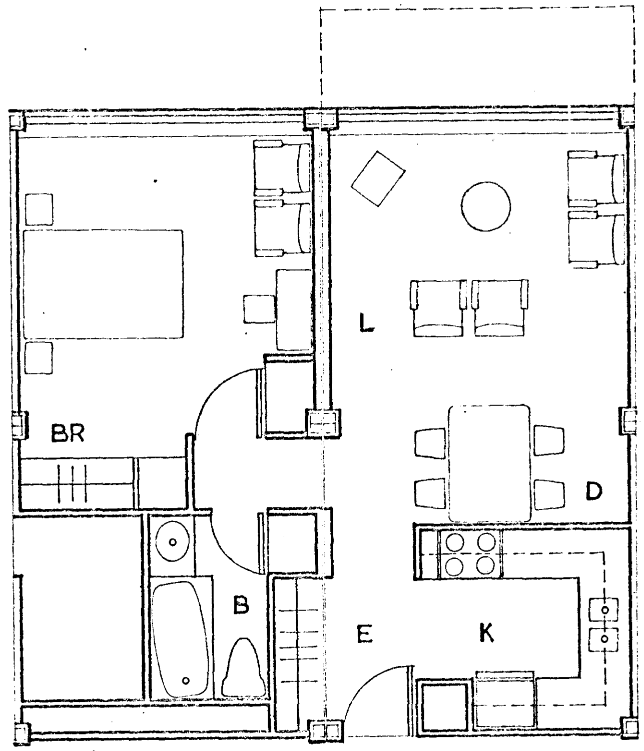
TYPICAL CIRCULATION AND SERVICE CORE UNITS (Fig. 46)

| | |
|---|---|
| Plan A: | Efficiency Unit |
| Plans B C D E F $G_1$ $H_1$ $H_2$ $L_2$: | One-bedroom Unit |
| Plans G H $H_3$ I J K L $L_1$ M N O P $Q_2$: | Two-bedroom Unit |
| Plans Q $Q_1$ R S $T_1 + T_3$: | Three-bedroom Unit |
| Plans $T_1 + T_2$: | Four-bedroom Unit |

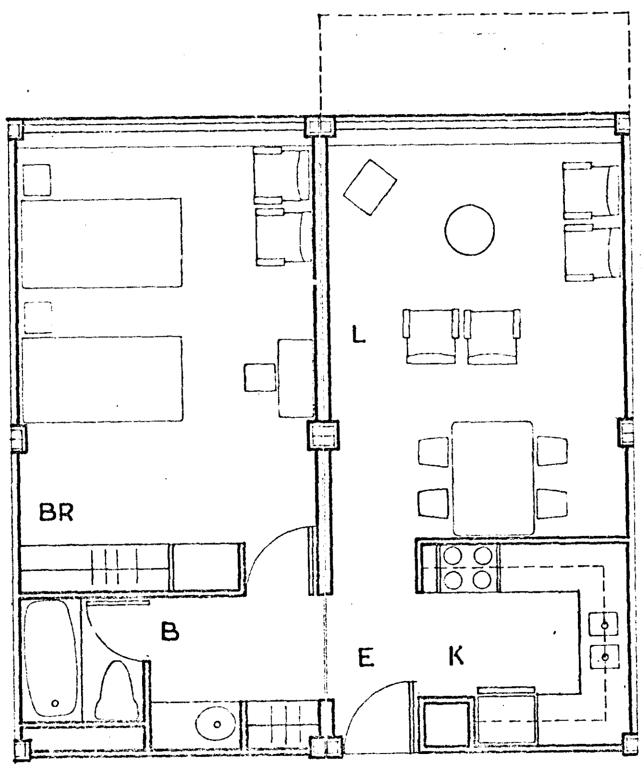
FIG. 28




A 386 SQ.FT

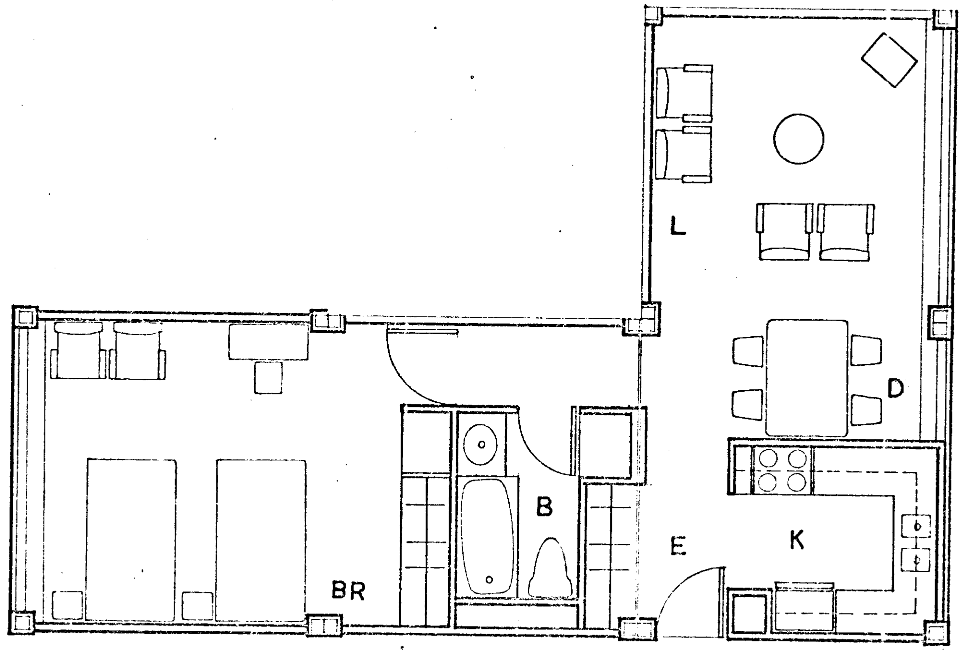



B 628 SQ.FT

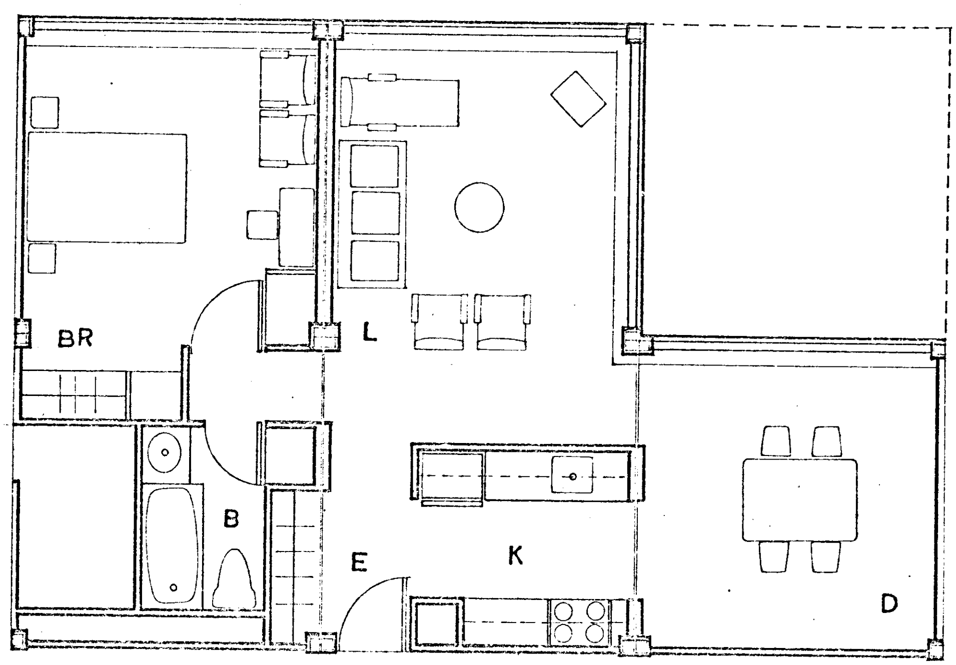



C 676 SQ.FT

SCALE $\frac{1}{8}''$ = 1'- 0" TYPICAL DWELLING UNIT PLANS



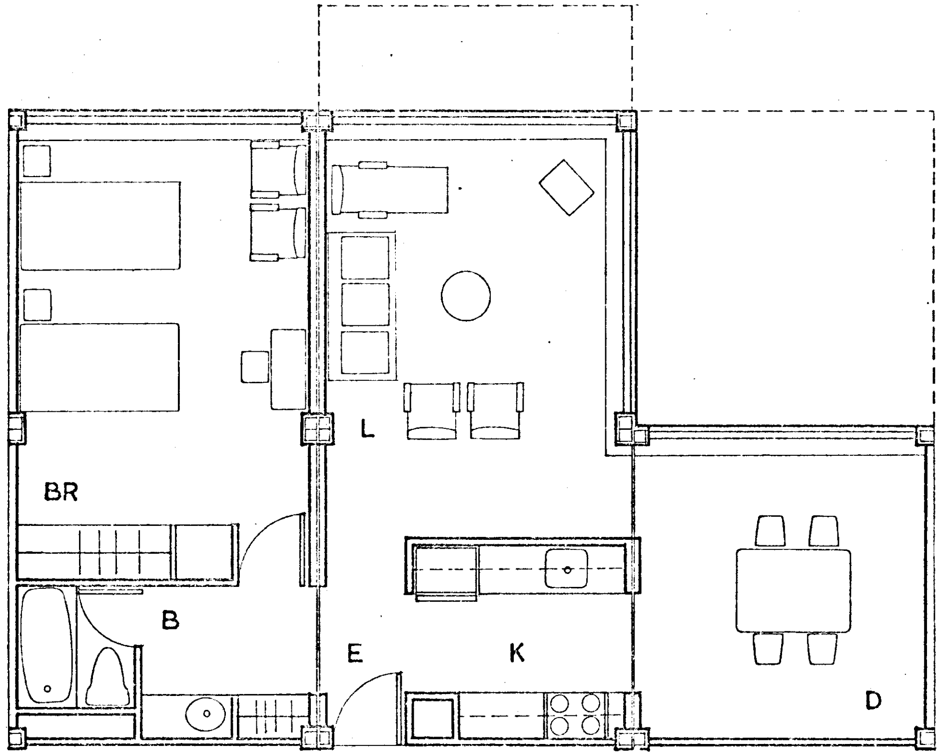

D 676 SQ.FT



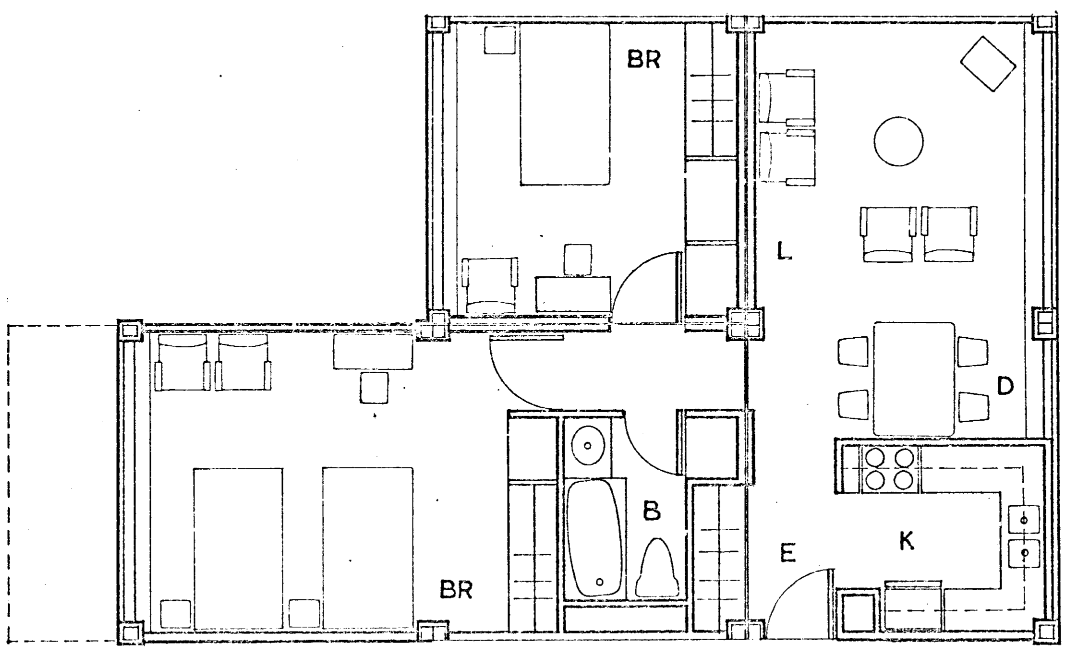

E 798 SQ.FT

SCALE $\frac{1}{8}''$ = 1′ - 0″ TYPICAL DWELLING UNIT PLANS

FIG. 30

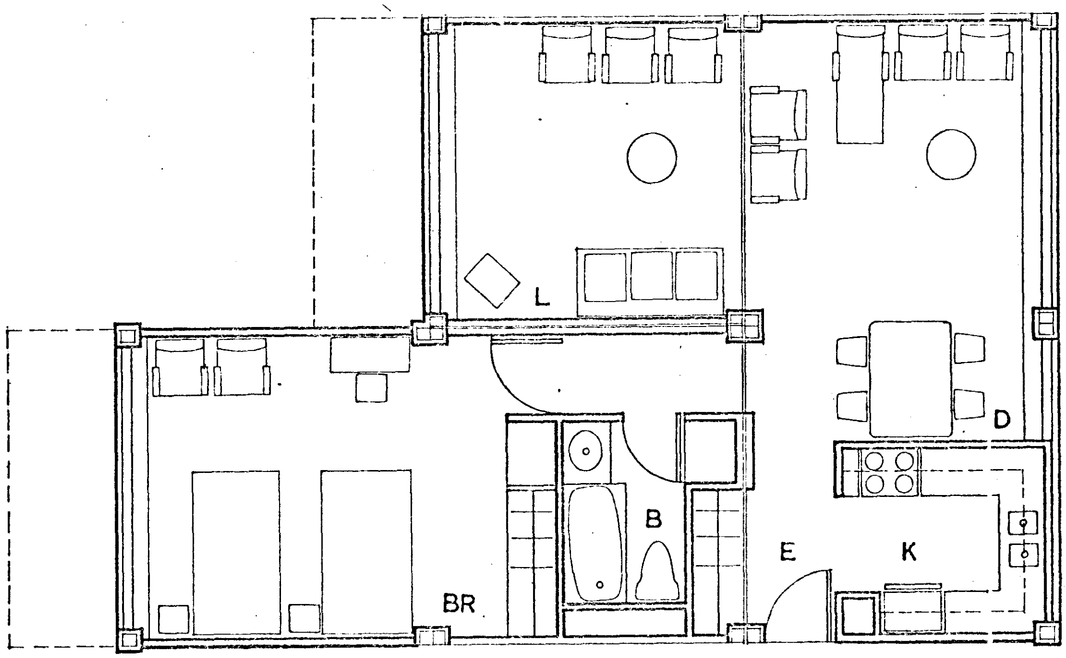



F 845 SQ.FT

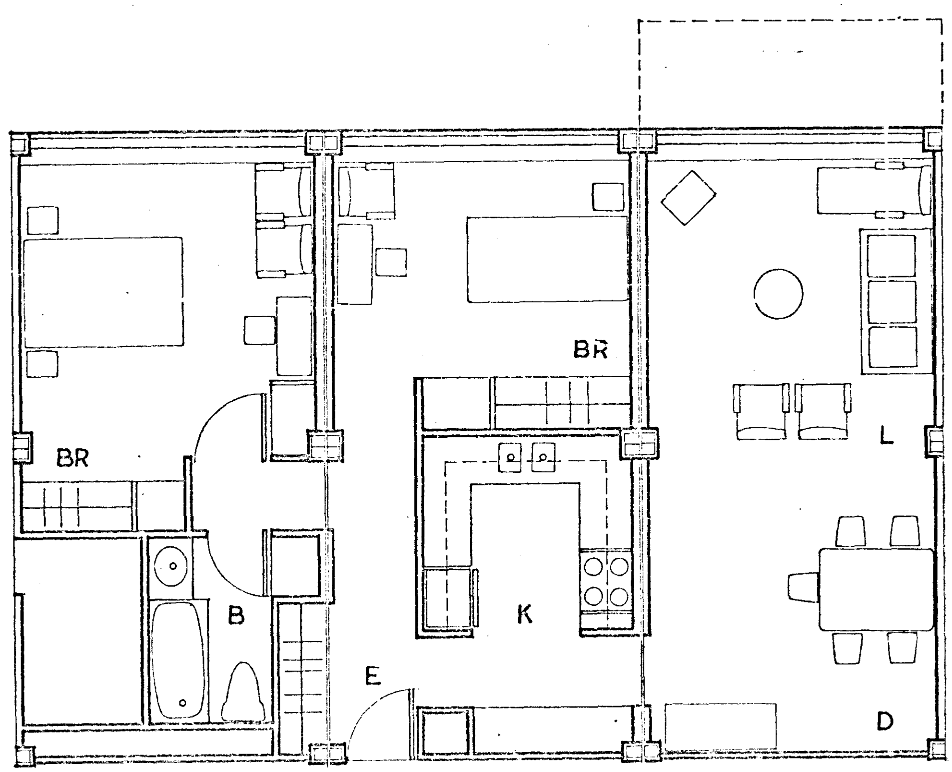



G 845 SQ.FT

SCALE $\frac{1}{8}'' = 1'-0''$ TYPICAL DWELLING UNIT PLANS



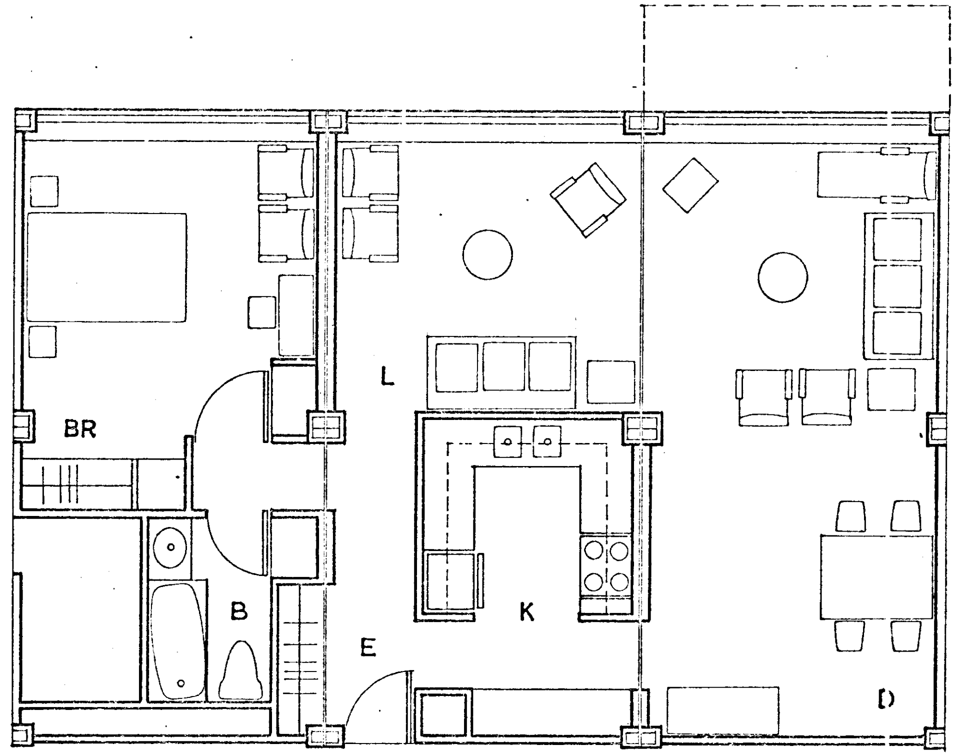

G1 845 SQ.FT



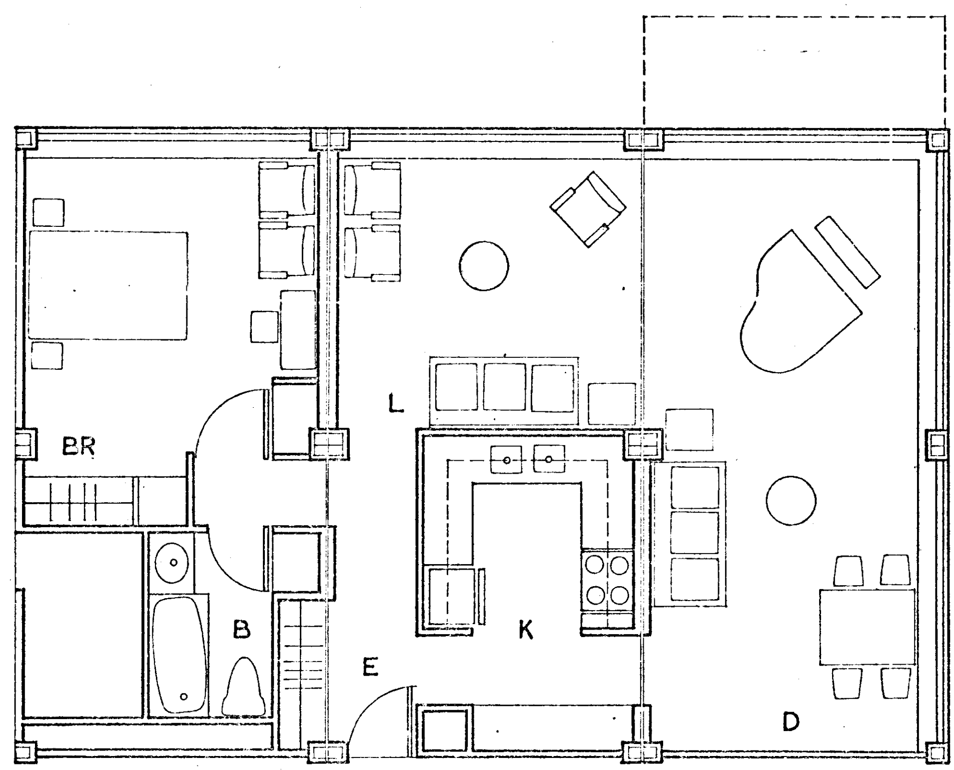

H 966 SQ.FT

SCALE 1/8" = 1' - 0" TYPICAL DWELLING UNIT PLANS

FIG. 32



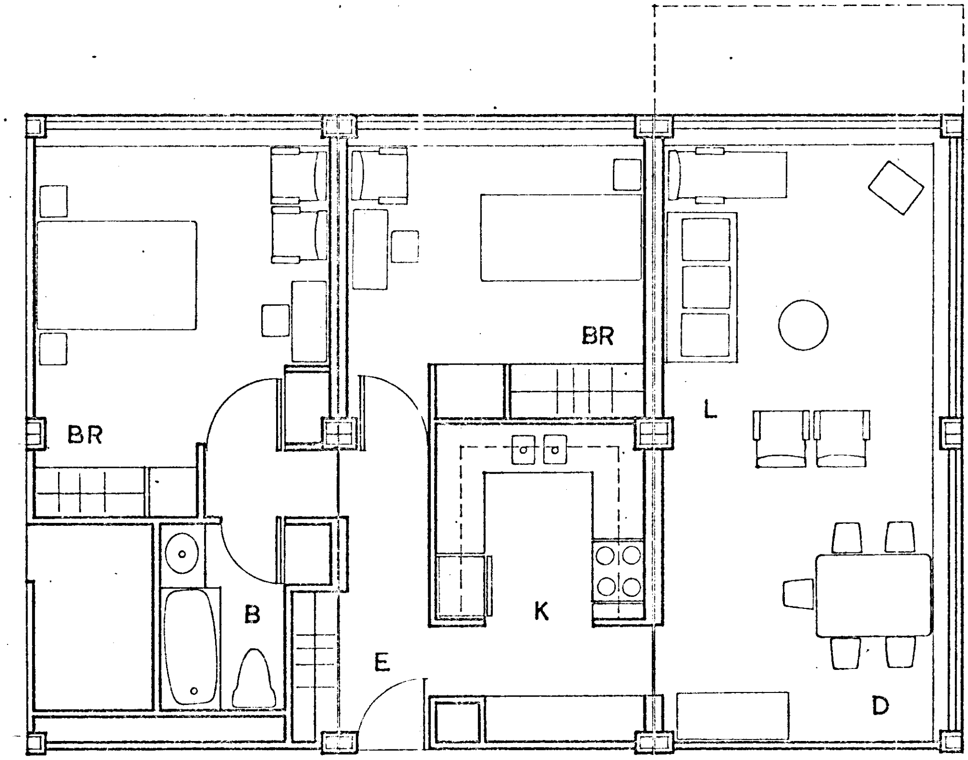

H1 966 SQ.FT



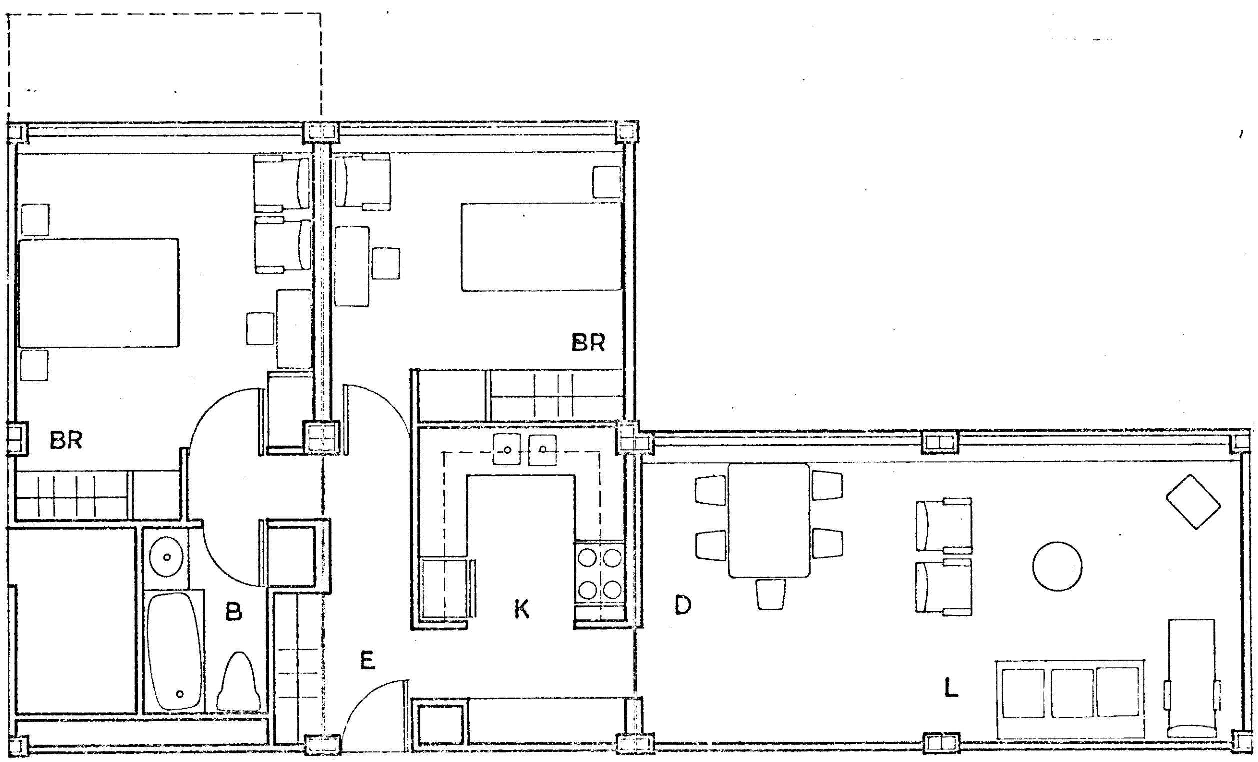

H2 966 SQ.FT

SCALE $\frac{1}{8}''$ = 1'- 0"    TYPICAL DWELLING UNIT PLANS

FIG.33

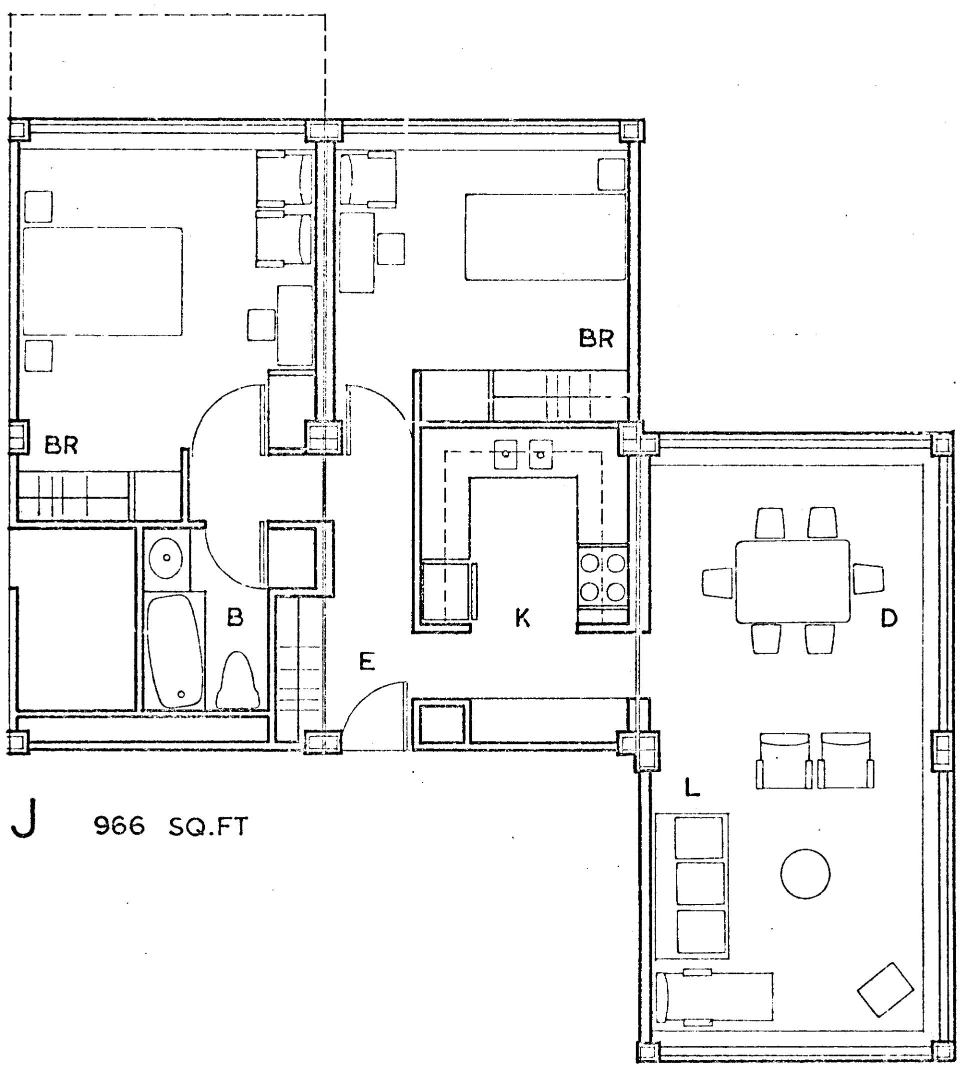



H3 966 SQ.FT



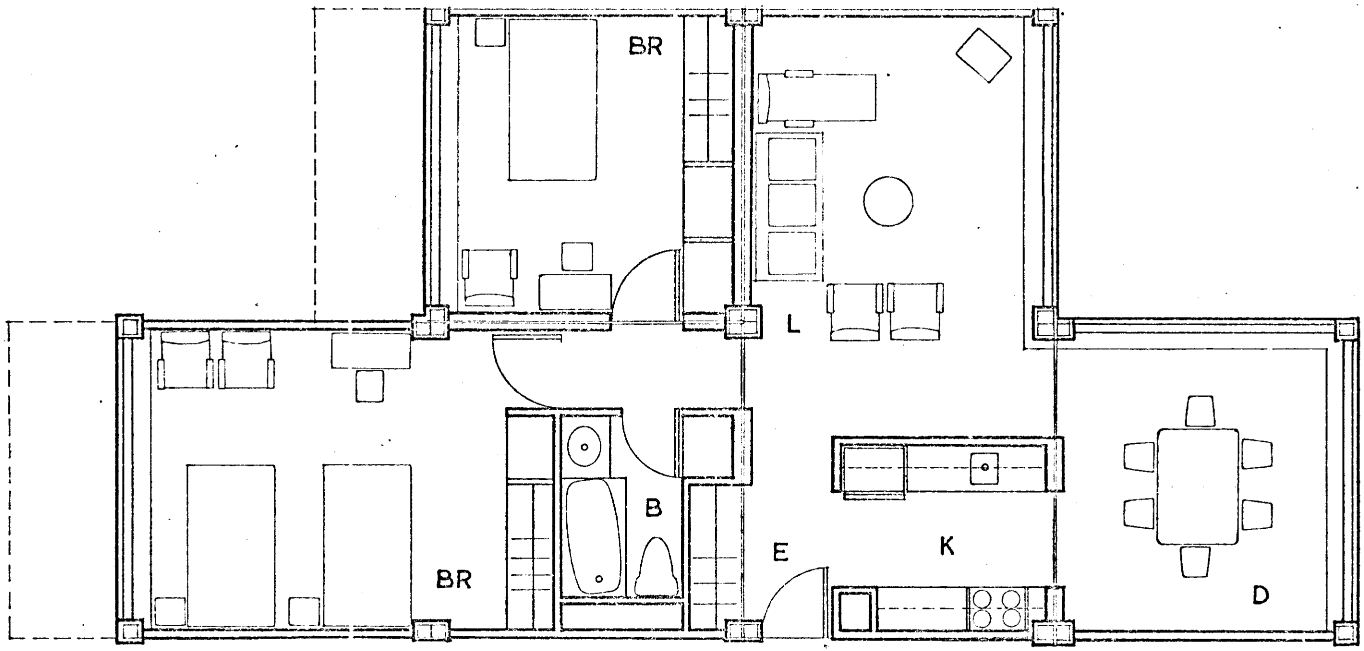

I 966 SQ.FT

SCALE $\frac{1}{8}'' = 1' - 0''$ TYPICAL DWELLING UNIT PLANS

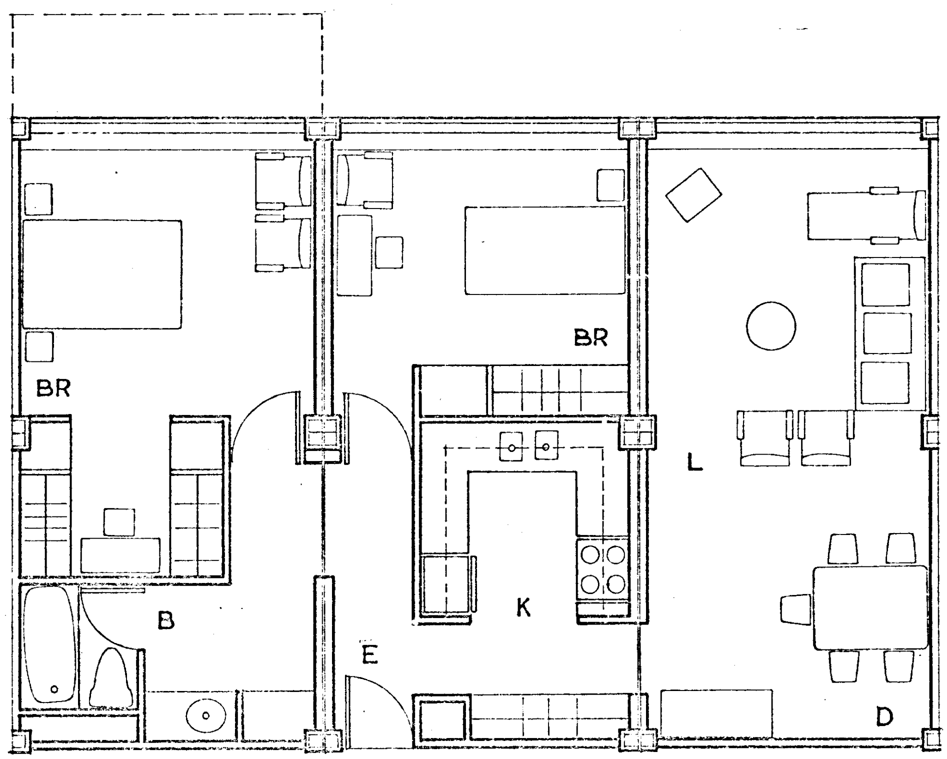



J 966 SQ.FT

SCALE $\frac{1}{8}''$ = 1'- 0" TYPICAL DWELLING UNIT PLANS



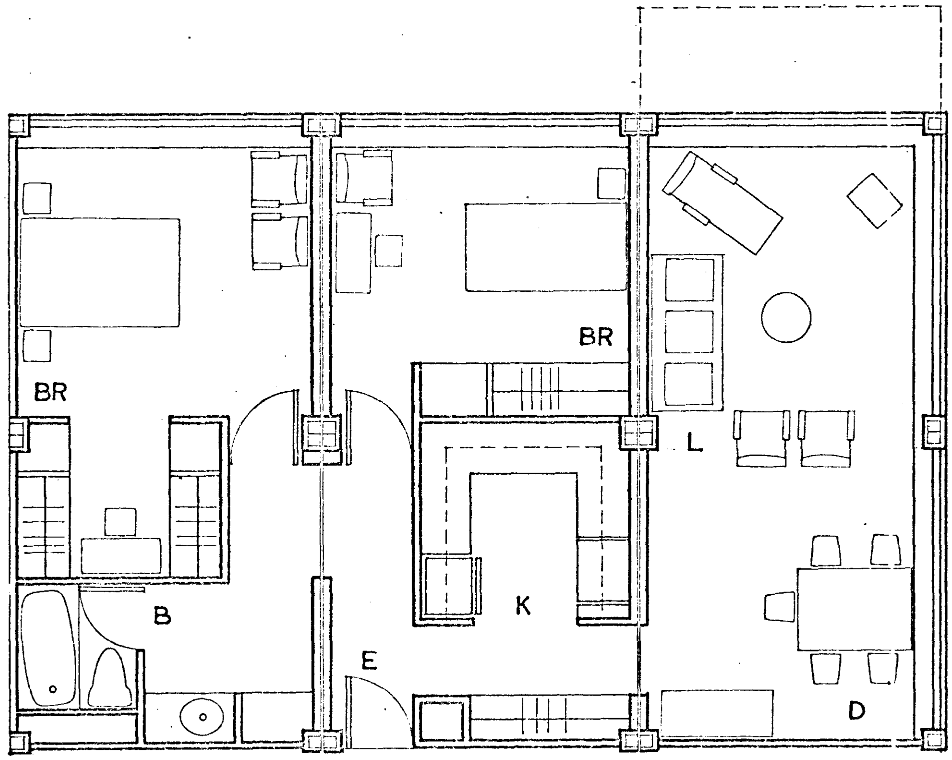

K 1014 SQ.FT



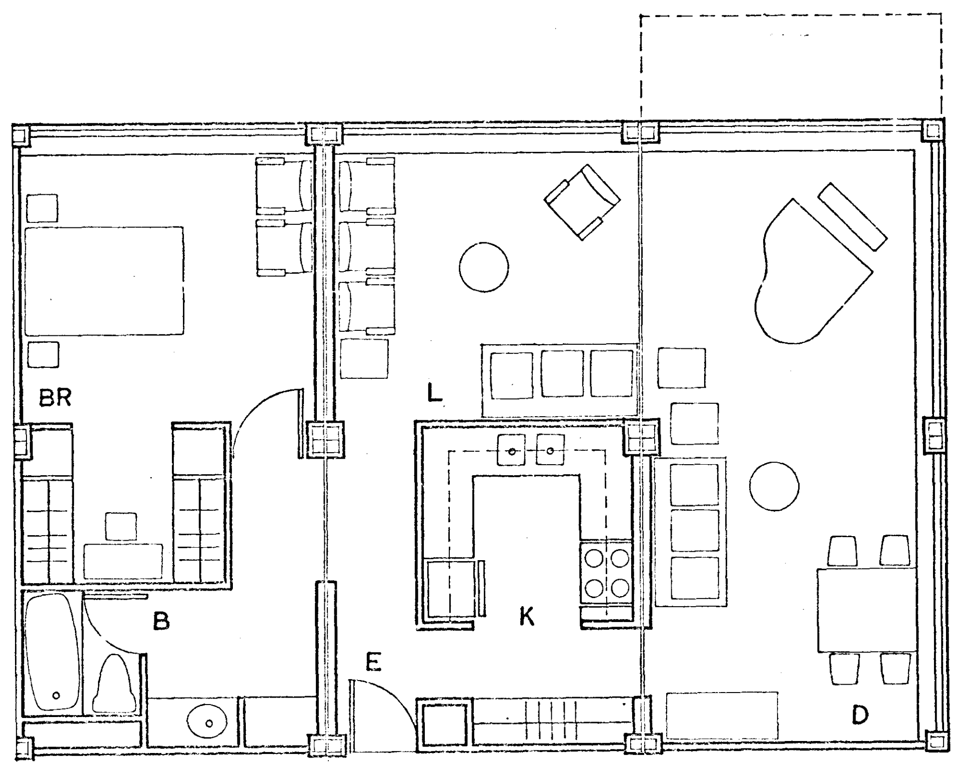

L 1014 SQ.FT

SCALE $\frac{1}{8}''$ = 1' - 0" TYPICAL DWELLING UNIT PLANS

FIG. 36

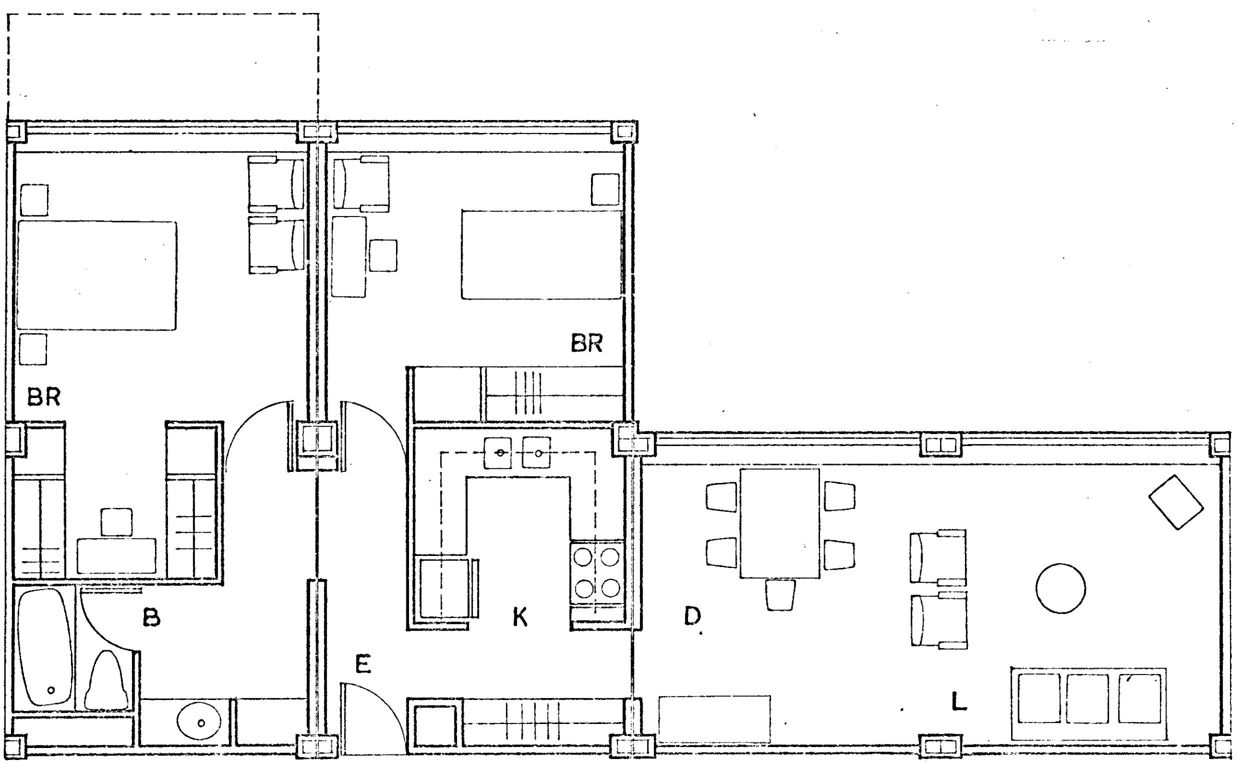



L1 1014 SQ.FT



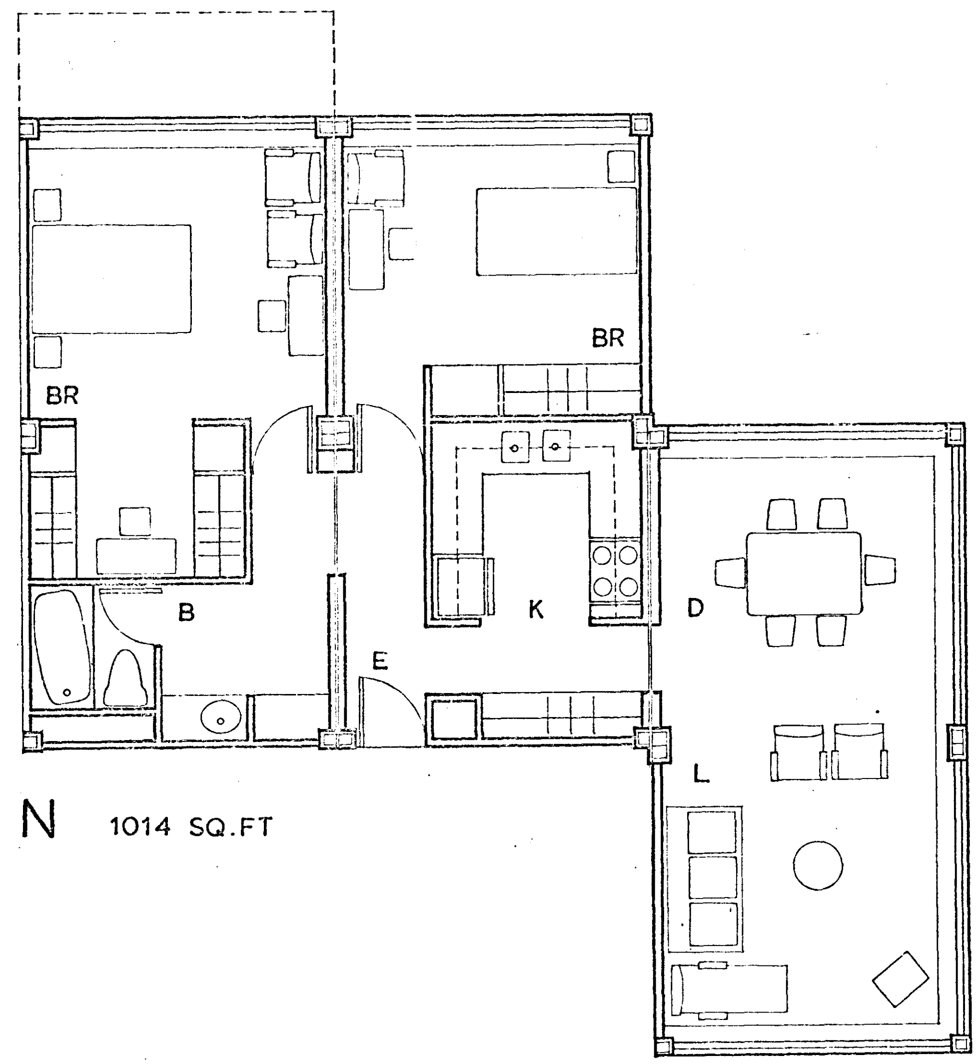

L2 1014 SQ.FT

SCALE $\frac{1}{8}''$ = 1'- 0" TYPICAL DWELLING UNIT PLANS

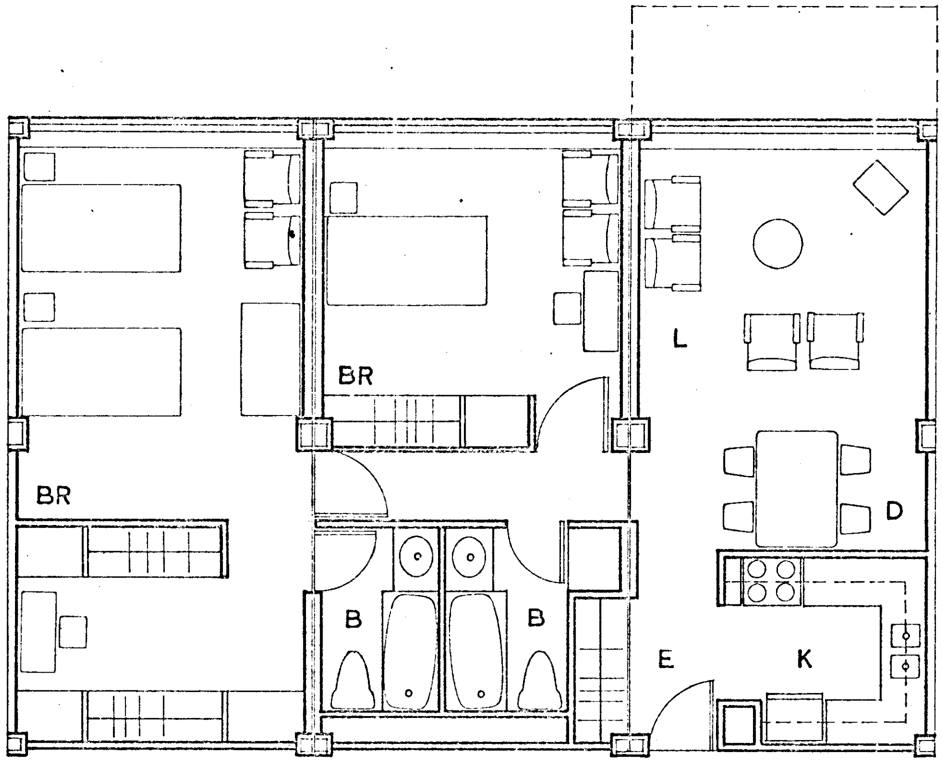



M 1014 SQ.FT

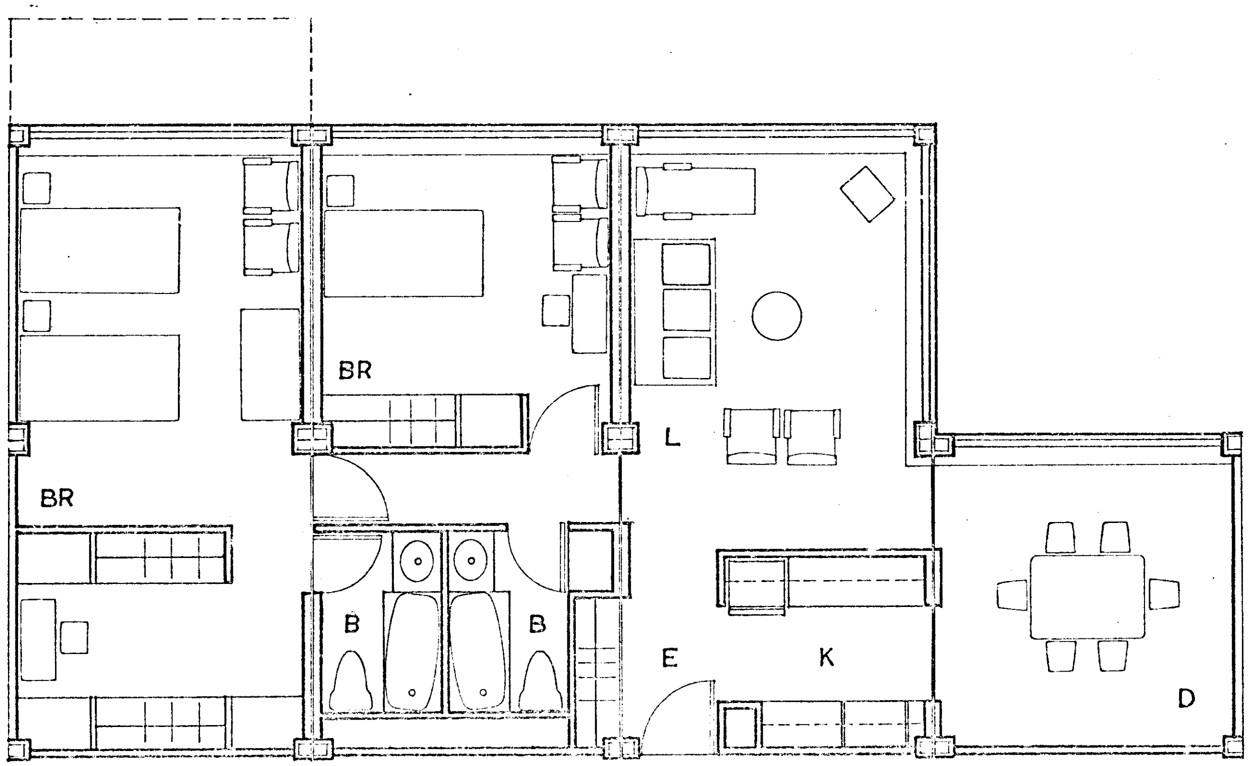
SCALE $\frac{1}{8}$" = 1'-0" TYPICAL DWELLING UNIT PLANS




SCALE $\frac{1}{8}''$ = 1'-0" TYPICAL DWELLING UNIT PLANS



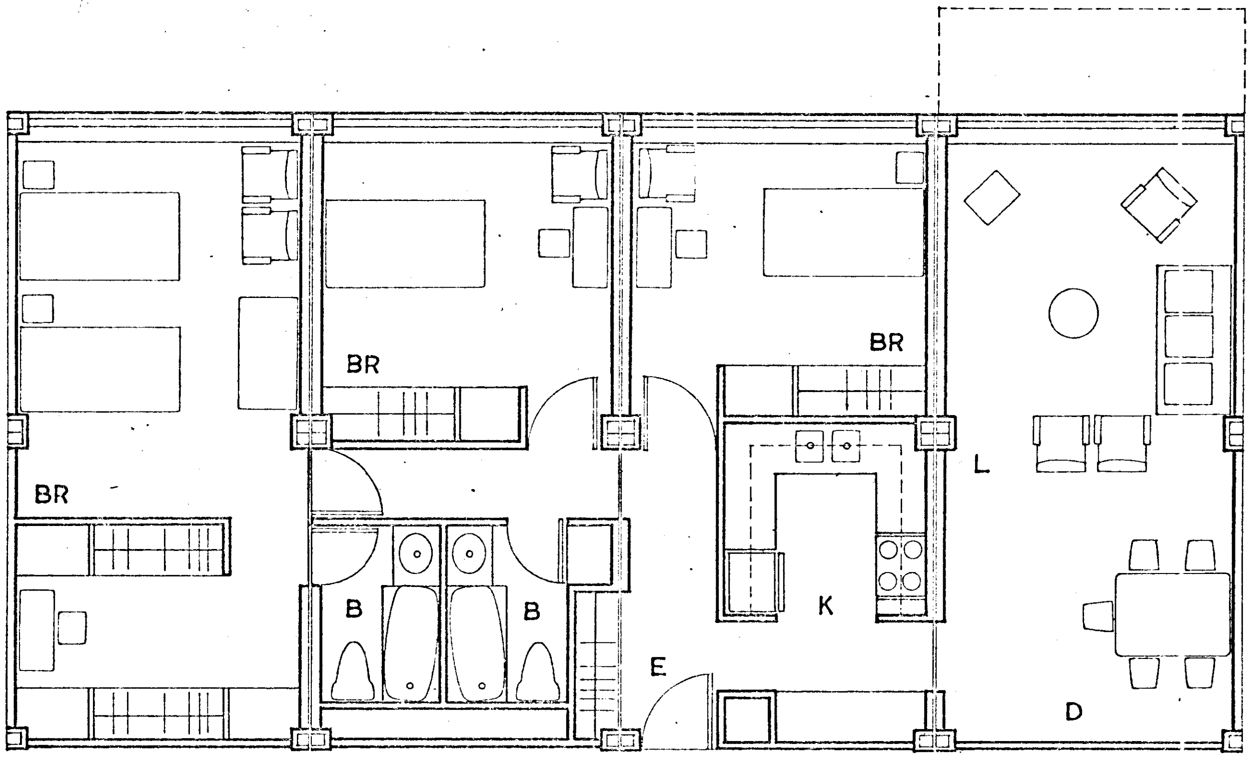

O 1014 SQ.FT



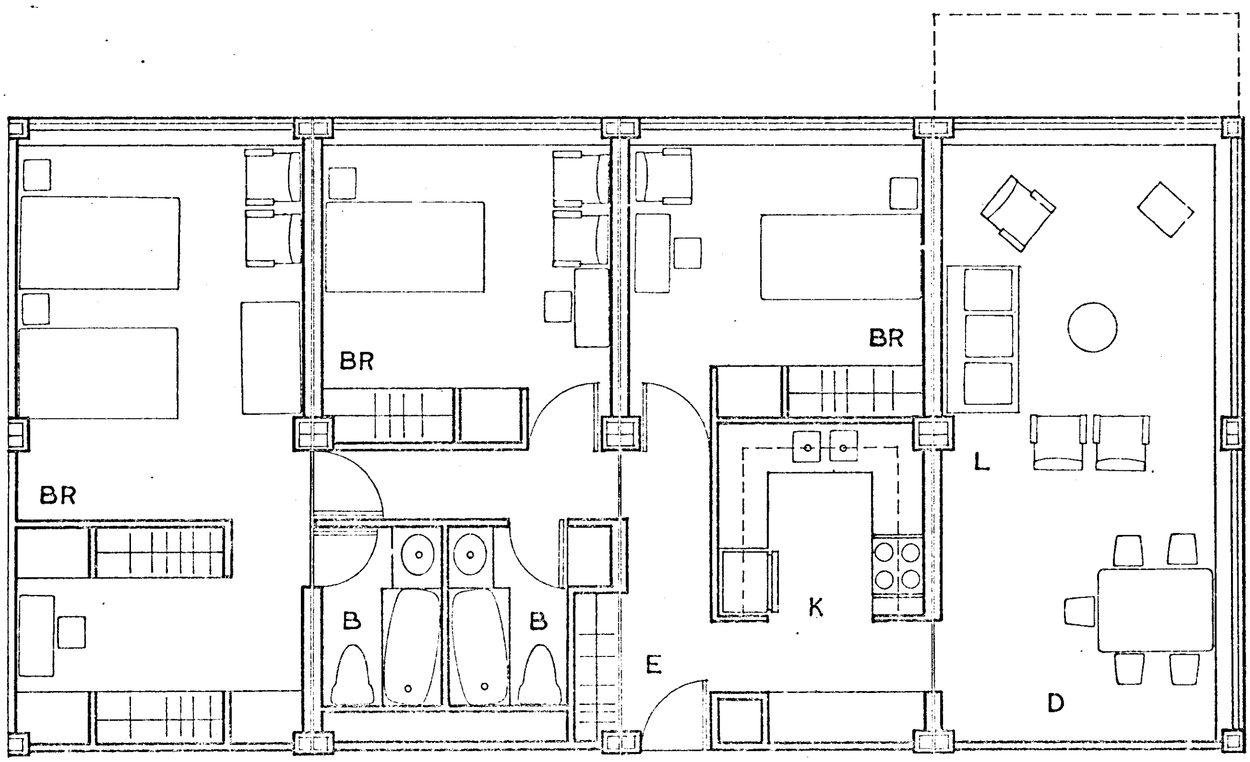

P 1183 SQ.FT

SCALE " = 1'-0" TYPICAL DWELLING UNIT PLANS

FIG. 40

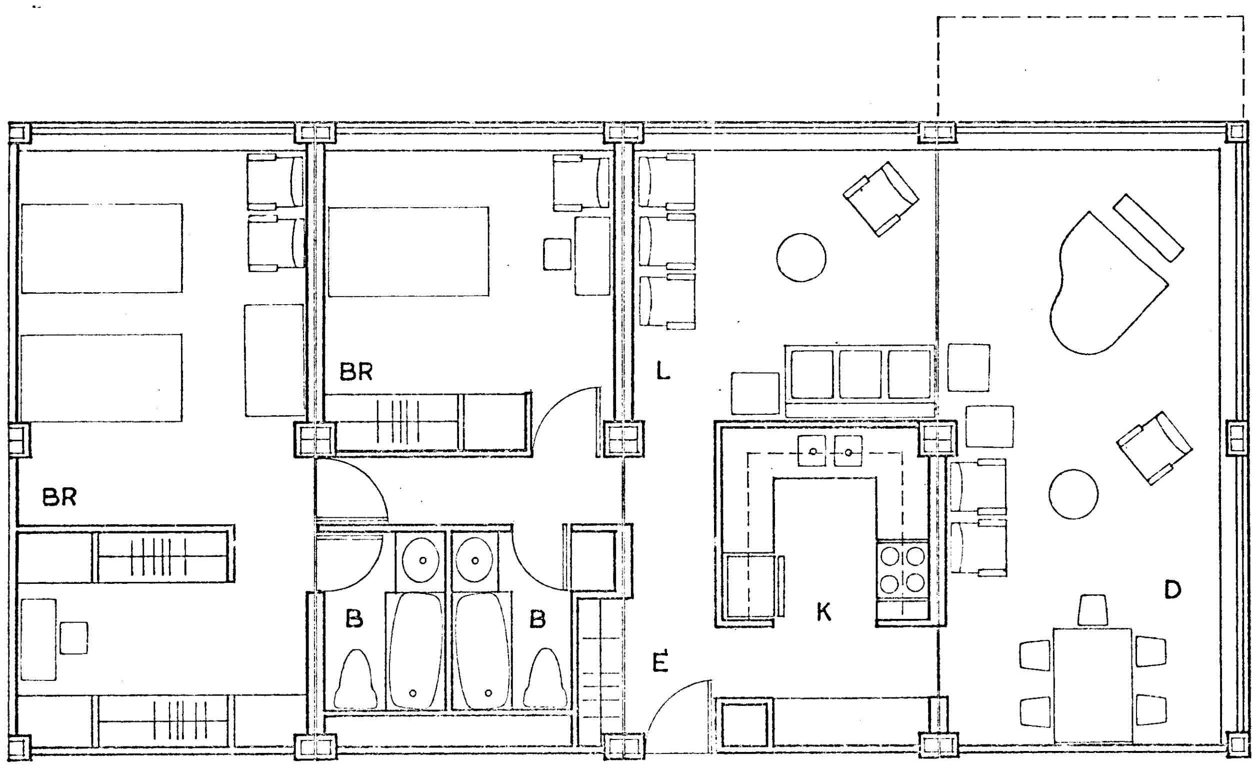



Q 1352 SQ.FT



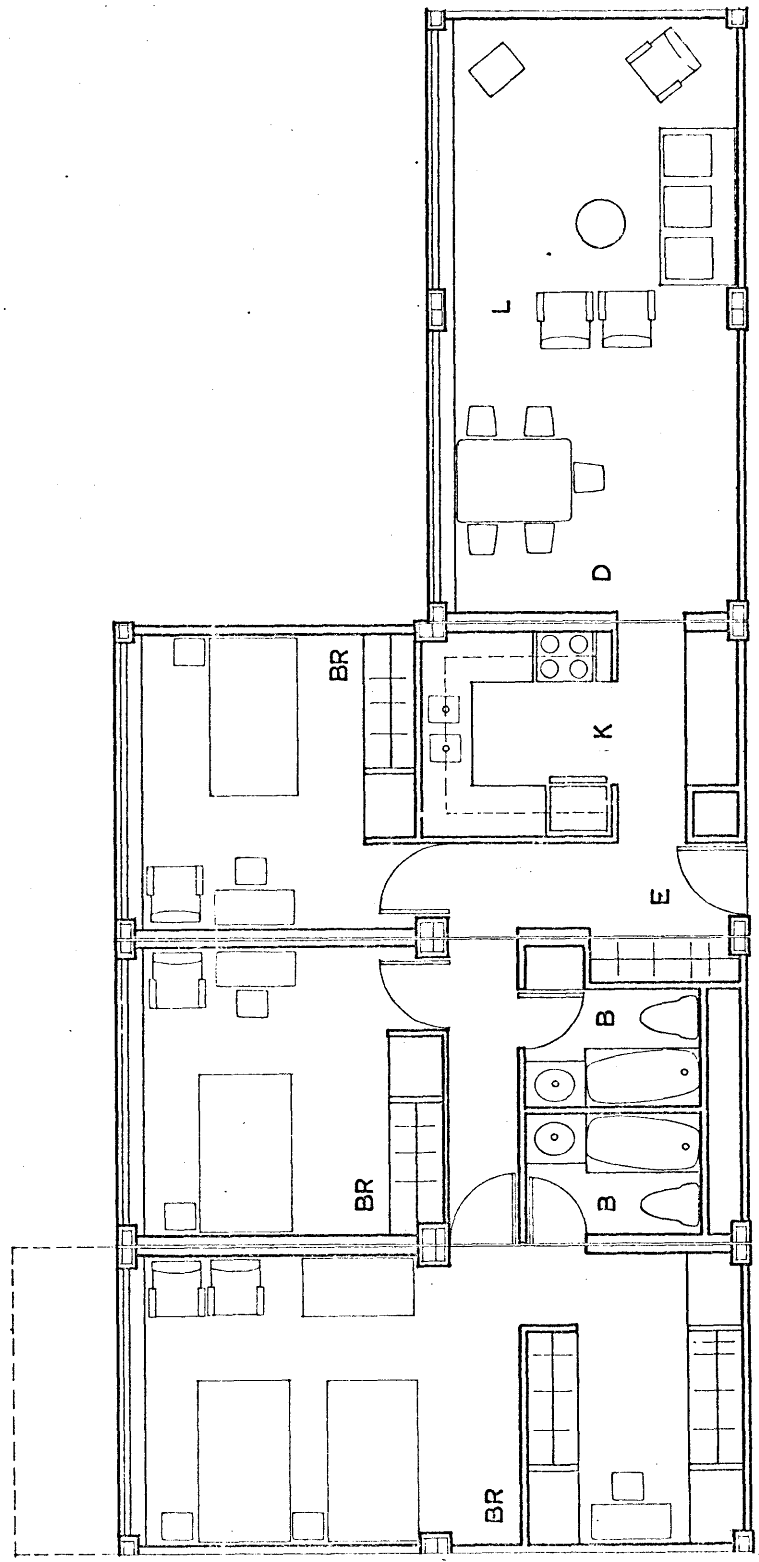

Q1 1352 SQ.FT

SCALE $\frac{1}{8}'' = 1' - 0''$ TYPICAL DWELLING UNIT PLANS



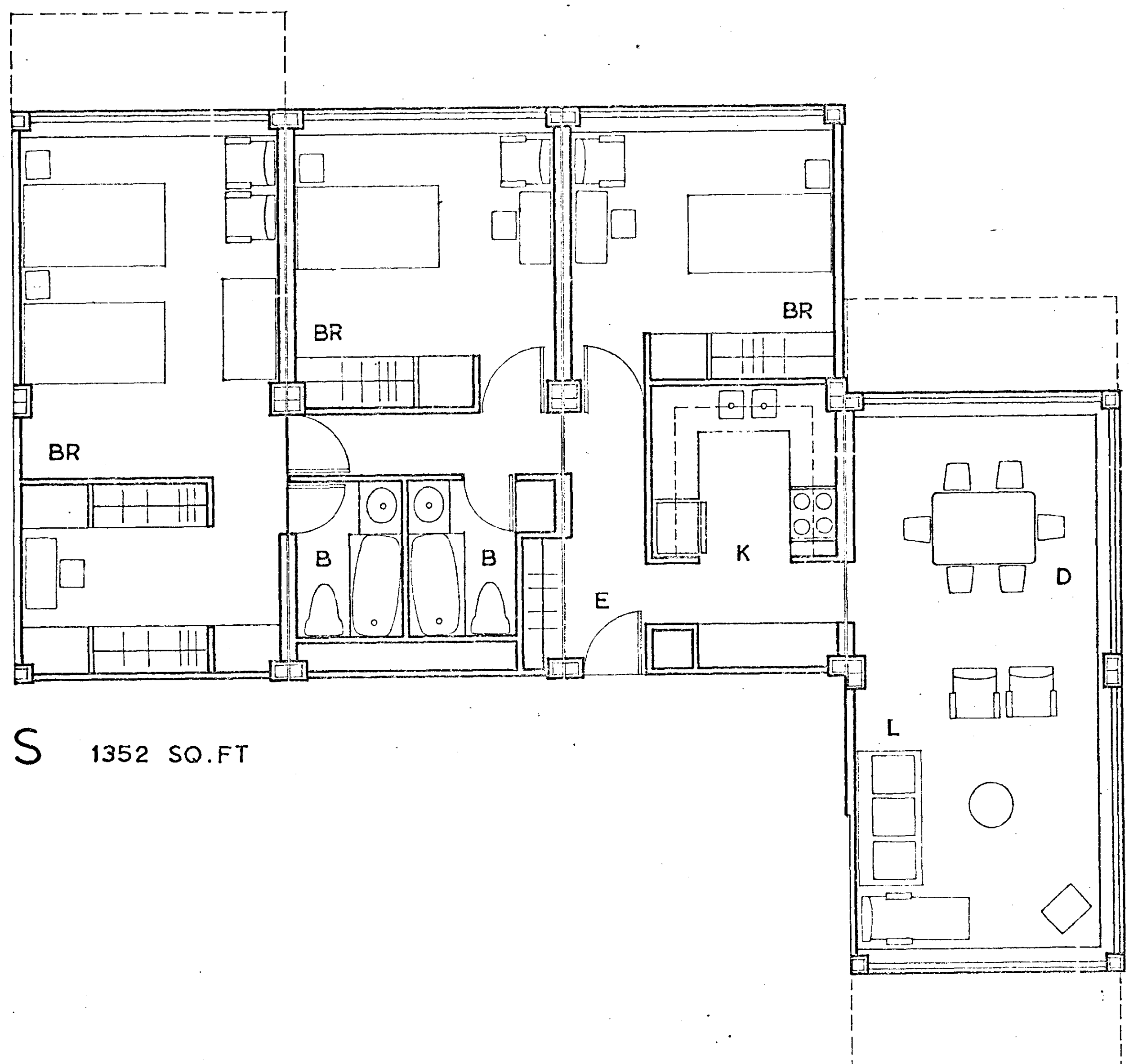

Q2 1352 SQ.FT

SCALE $\frac{1}{8}'' = 1' - 0''$ TYPICAL DWELLING UNIT PLANS

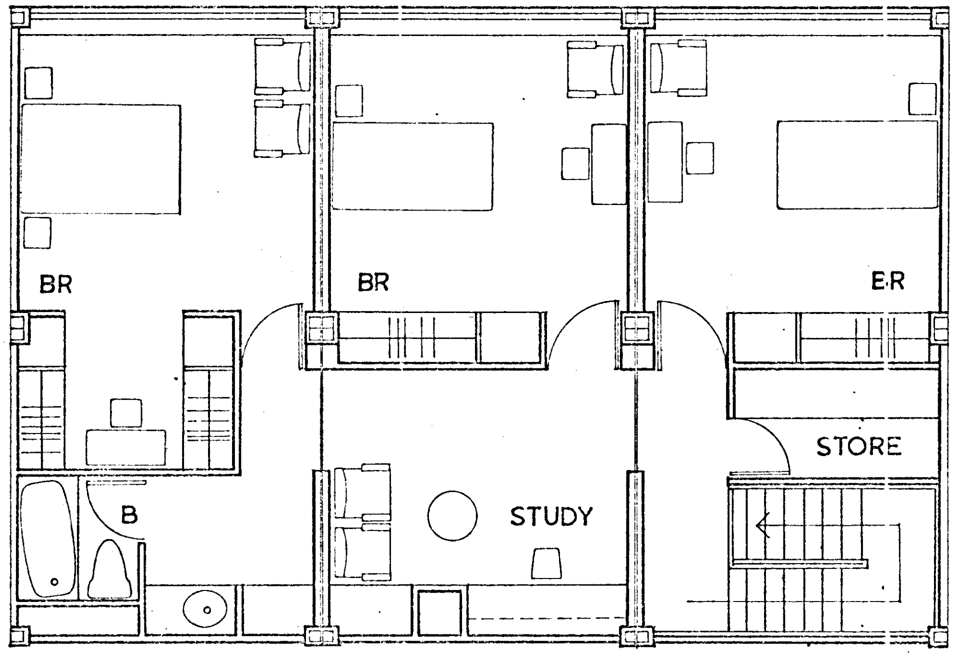



R 1352 SQ.FT

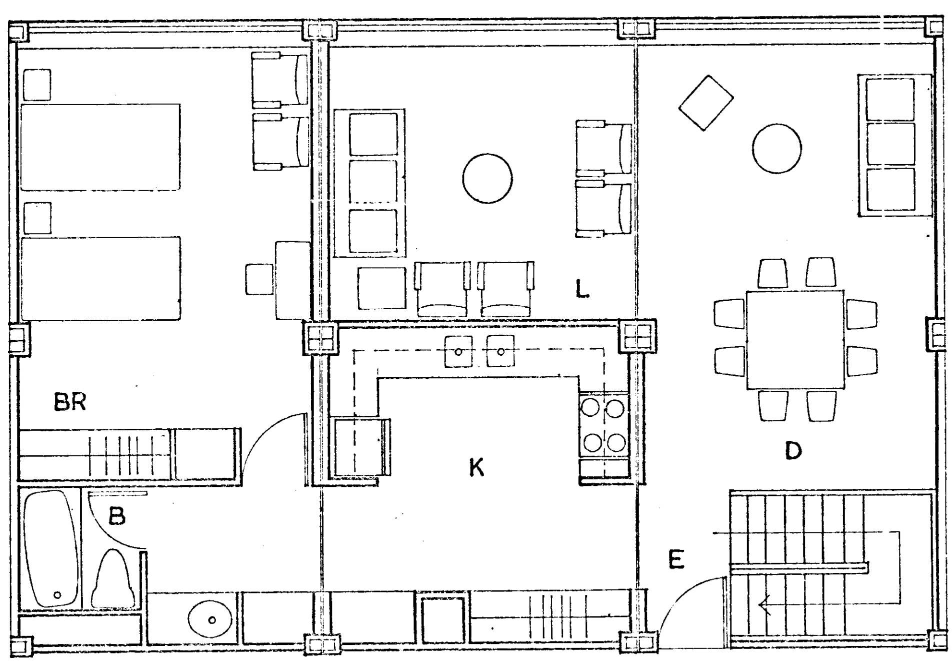
SCALE 1/8" = 1'-0" TYPICAL DWELLING UNIT PLANS




SCALE $\frac{1}{8}''$ = 1'-0"     TYPICAL DWELLING UNIT PLANS

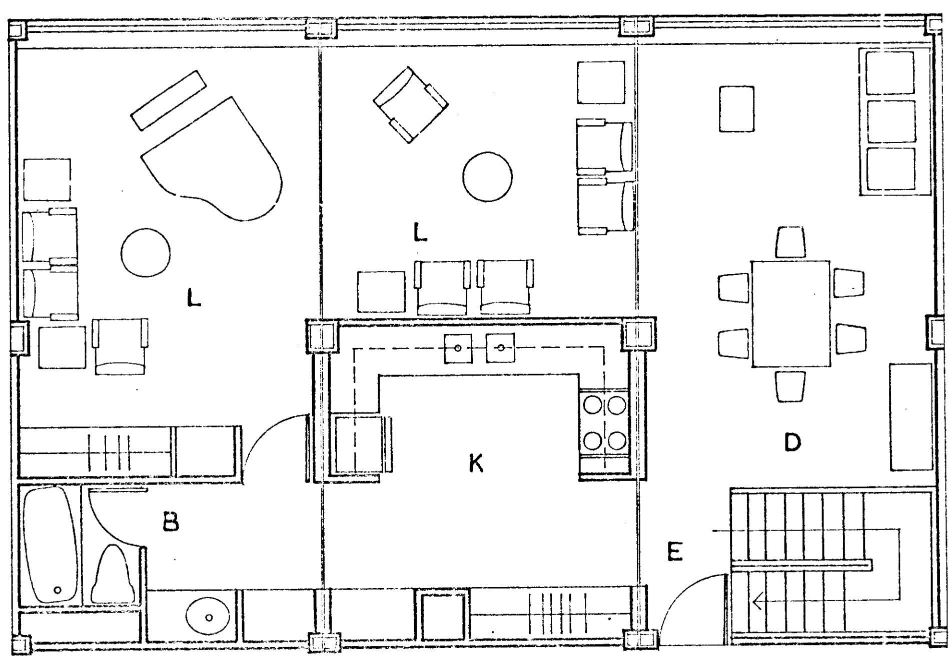



T1 1014 SQ.FT



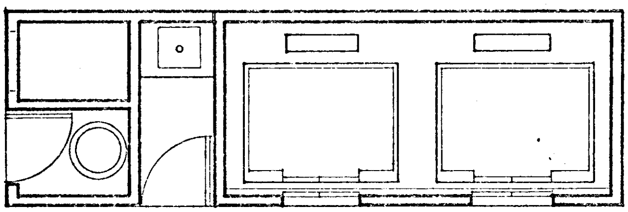

T2 1014 SQ.FT

SCALE $\frac{1}{8}''$ = 1'-0" TYPICAL DWELLING UNIT PLANS

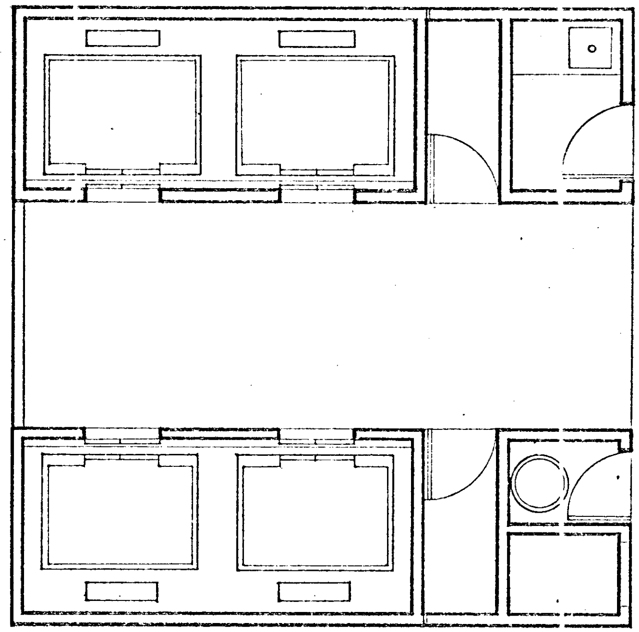



T3 1014 SQ.FT

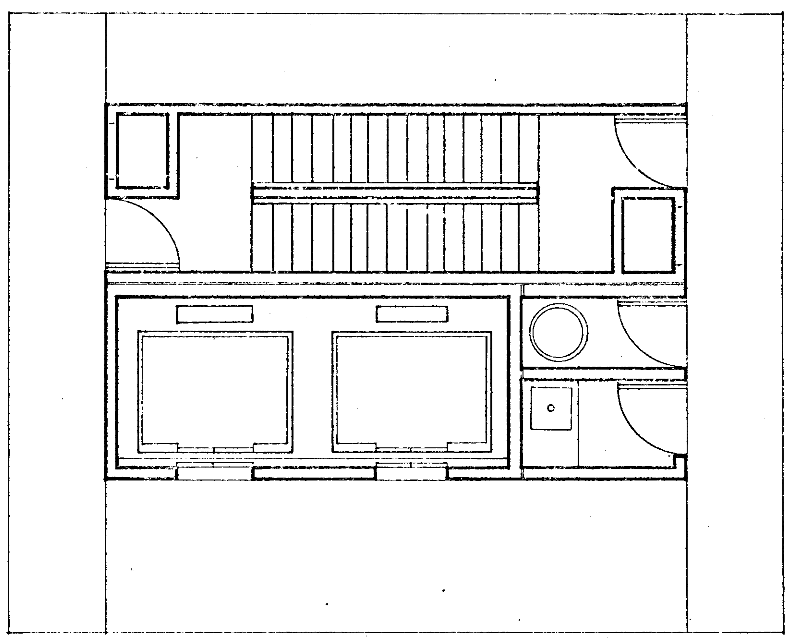
SCALE $\frac{1}{8}''$ = 1' - 0" TYPICAL DWELLING UNIT PLANS



TWO ELEVATOR CORE



FOUR ELEVATOR CORE



TWO ELEVATOR CORE WITH STAIR CASE

SCALE $\frac{1}{8}'' = 1'-0''$

# TYPICAL CIRCULATION & SERVICE CORE UNIT

FLOOR PLANS OF DWELLING UNITS:

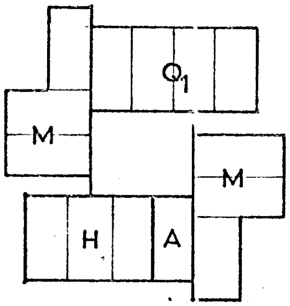
Multi-family high rise (Figs. 47 - 72)

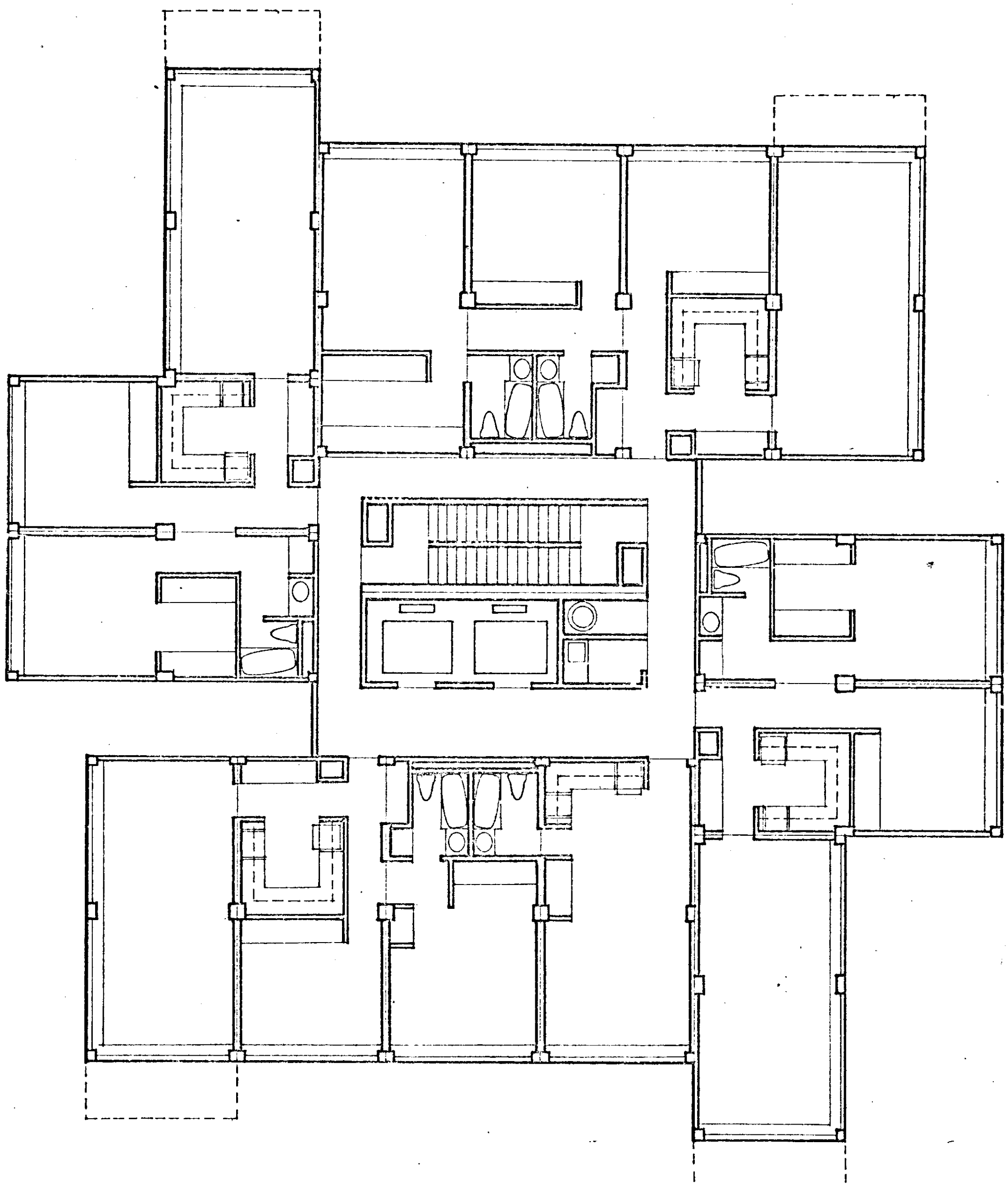
Multi-family low rise (Figs. 73 - 79)

Single-family attached (Fig. 80)

C: Public building circulation and service core area.

G: Gross area of dwelling units excluding exterior space and C.



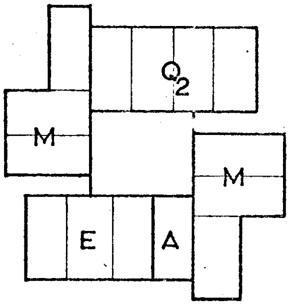



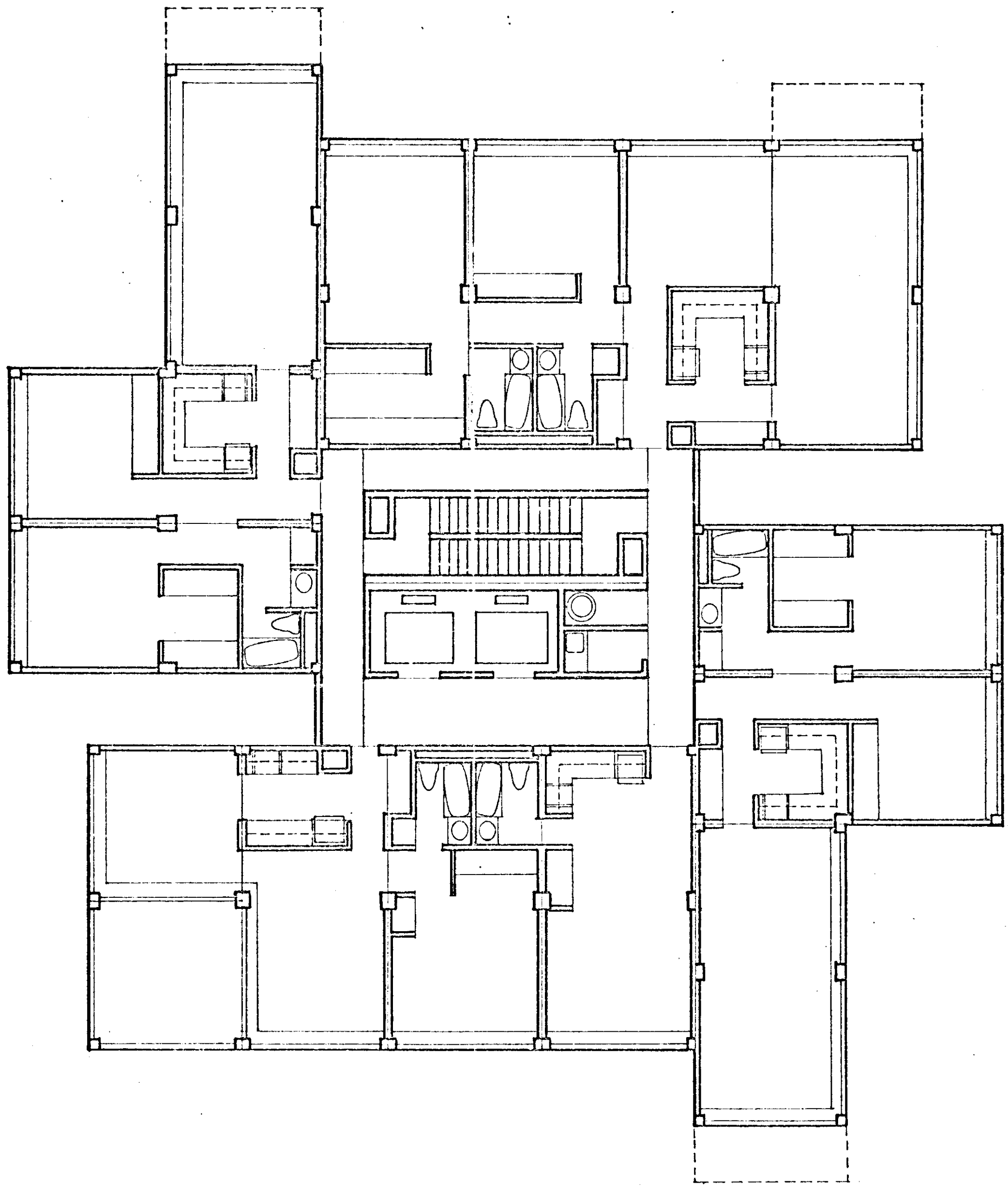
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI-FAMILY HIGH RISE



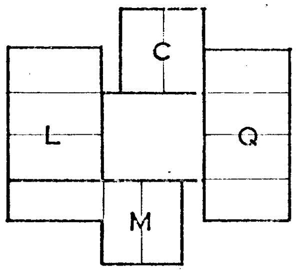



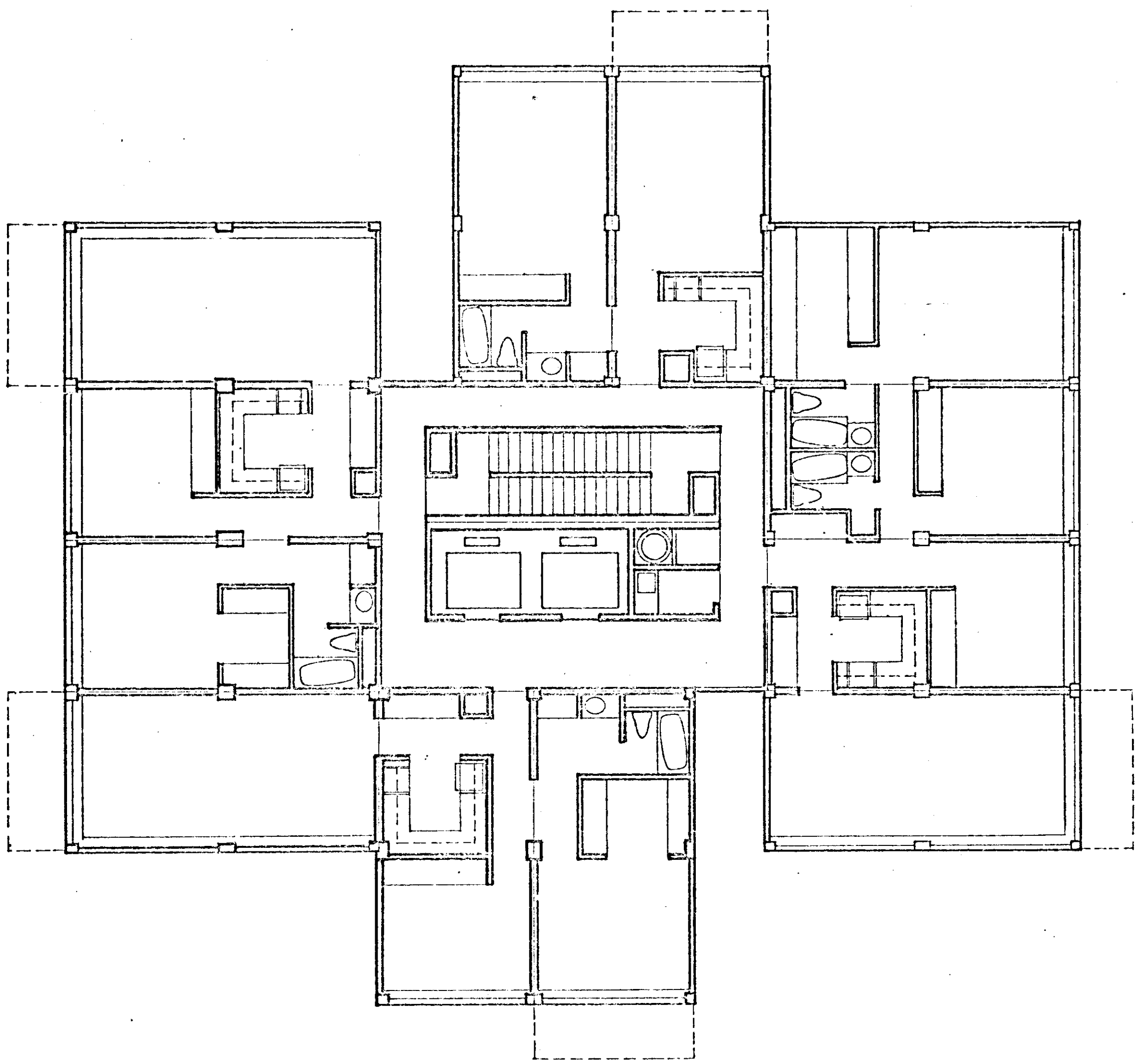
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI-FAMILY HIGH RISE



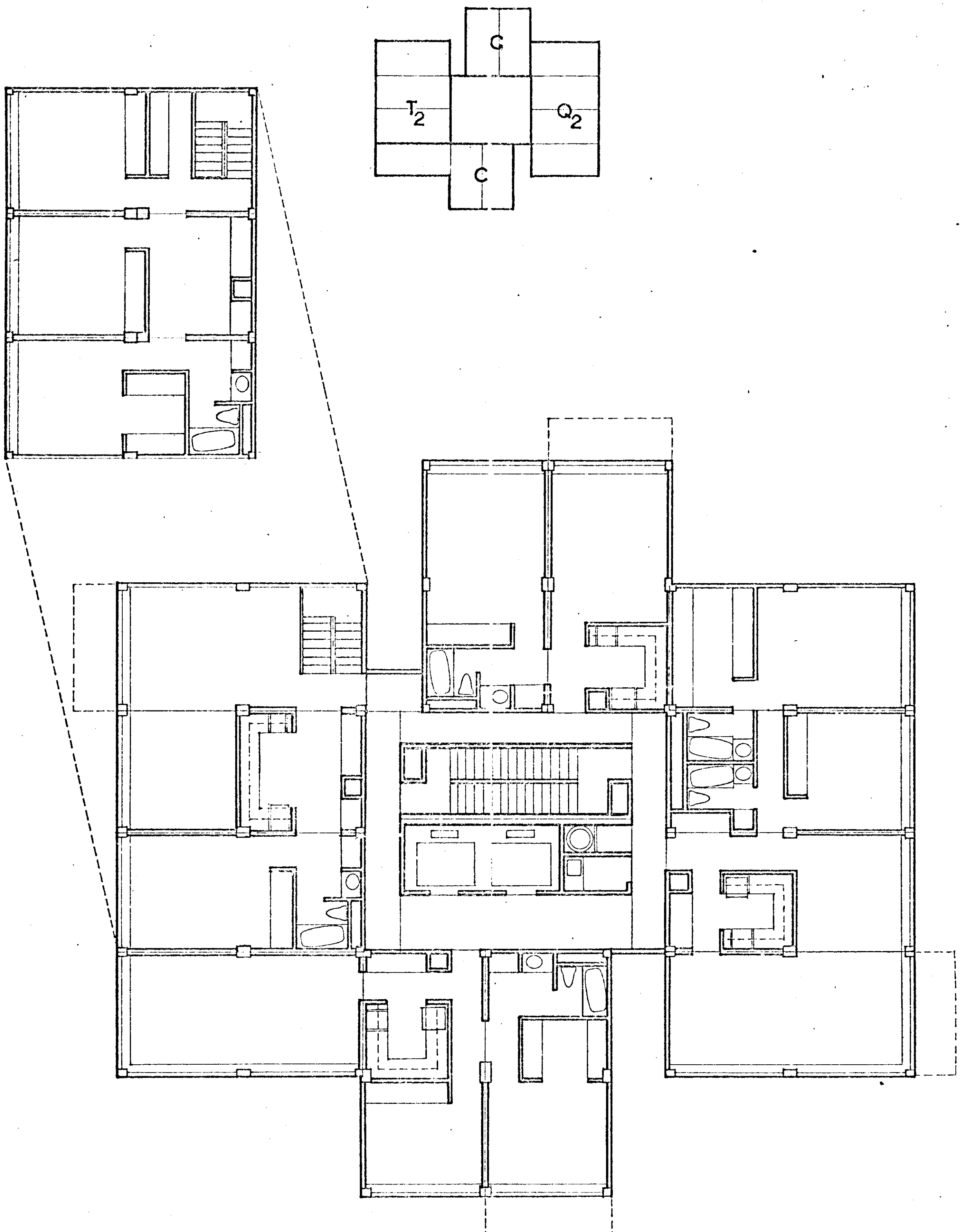



C:G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}$" = 1'-0"

MULTI-FAMILY HIGH RISE

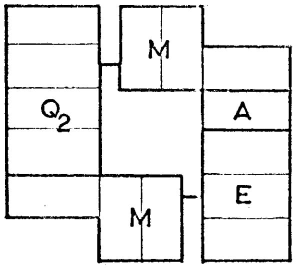


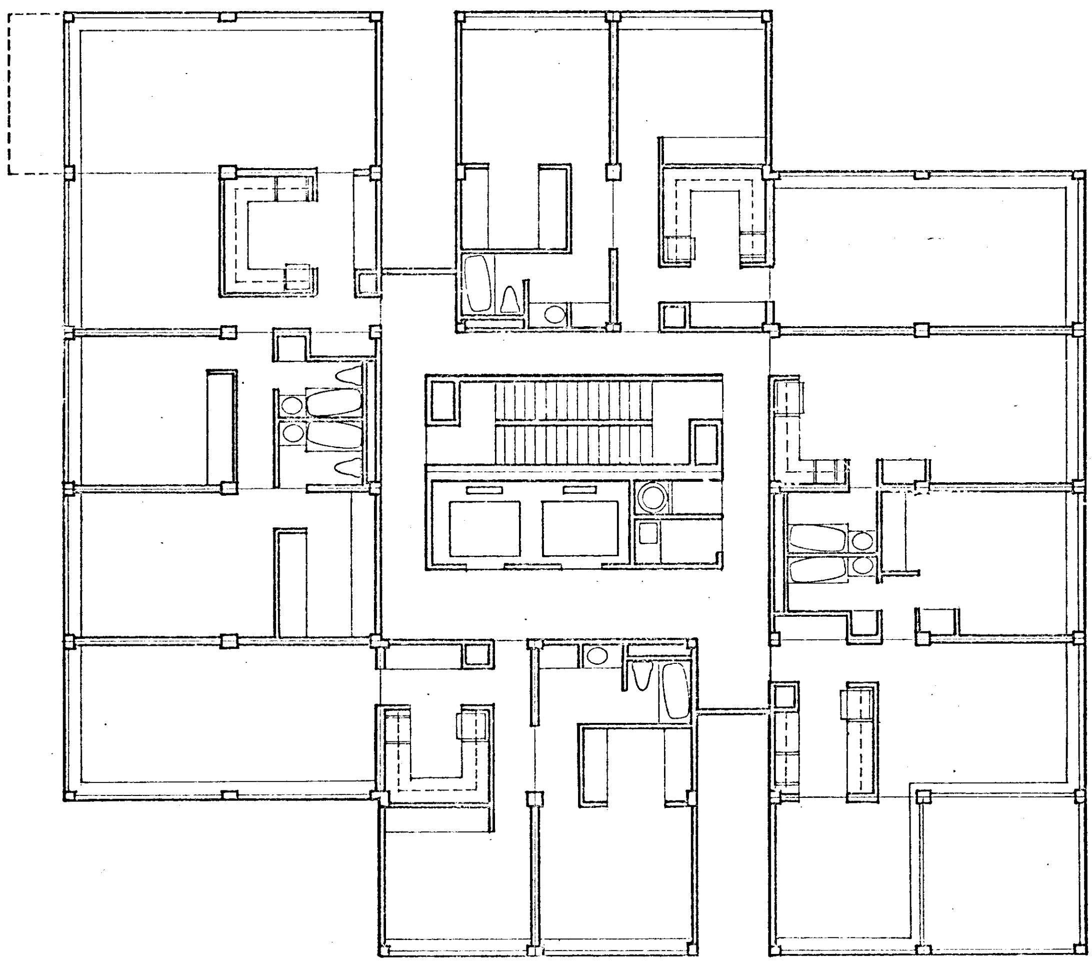

C : G 1 : 4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0"

# MULTI-FAMILY HIGH RISE



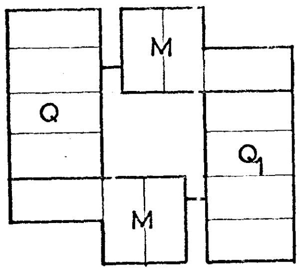



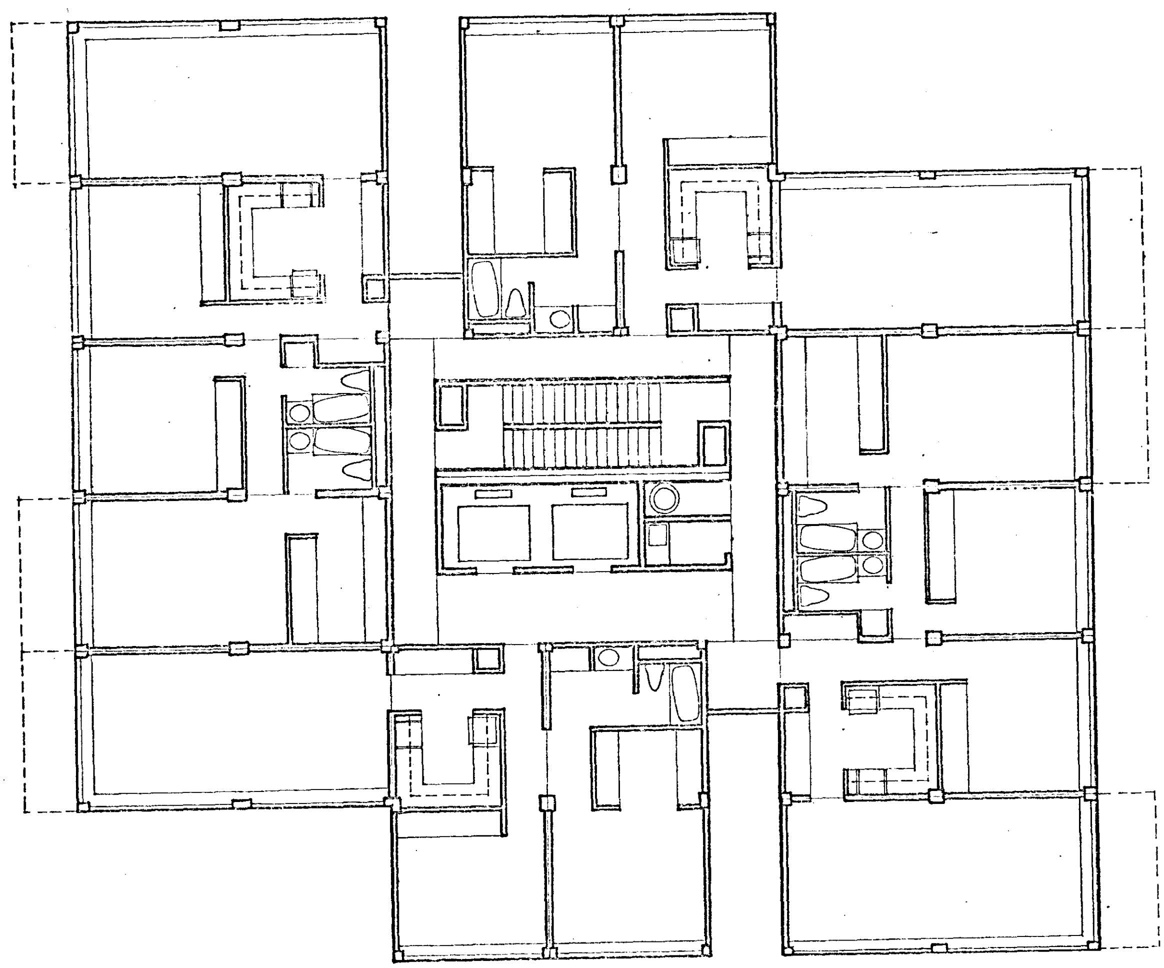
C : G 1 : 4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI--FAMILY HIGH RISE



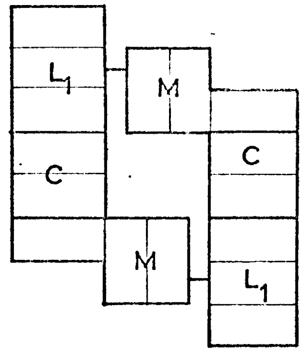



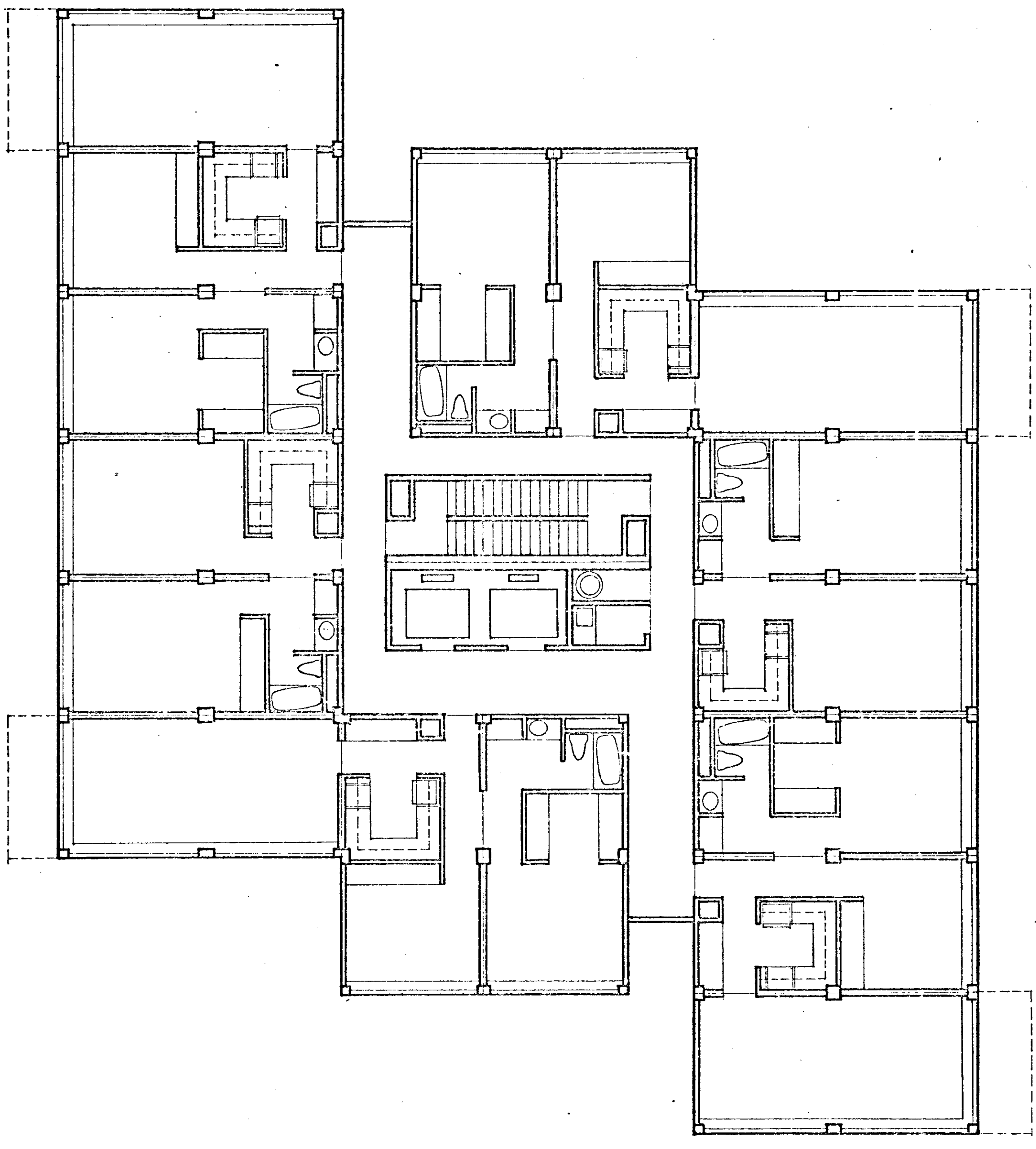
C : G    1 : 4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0"

MULTI-FAMILY HIGH RISE



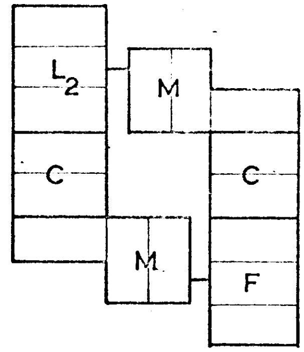



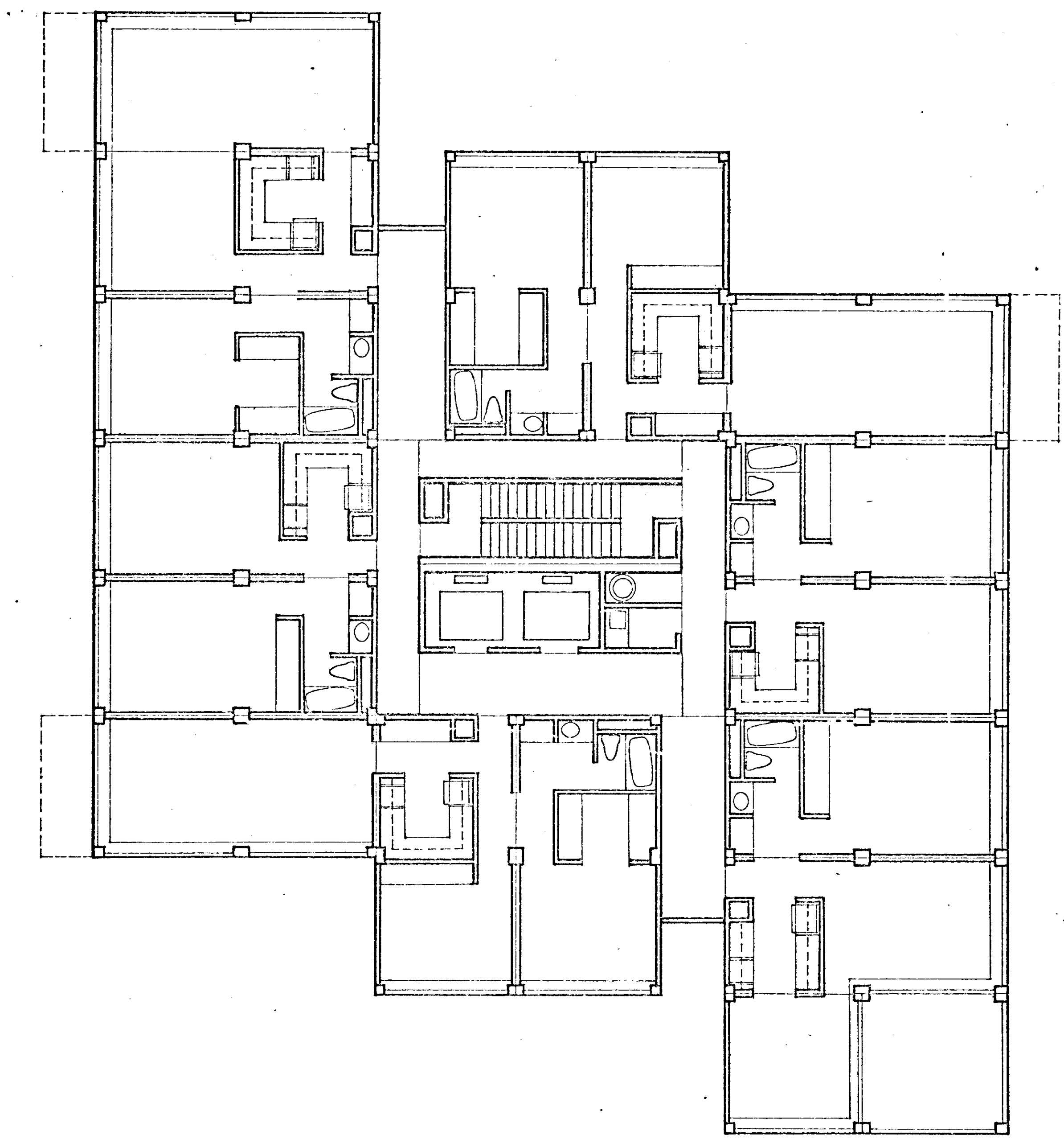
C : G 1 : 4.8

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

MULTI-FAMILY HIGH RISE



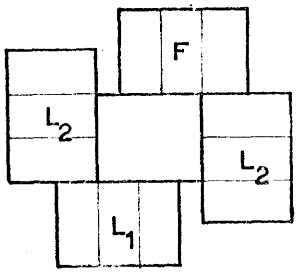



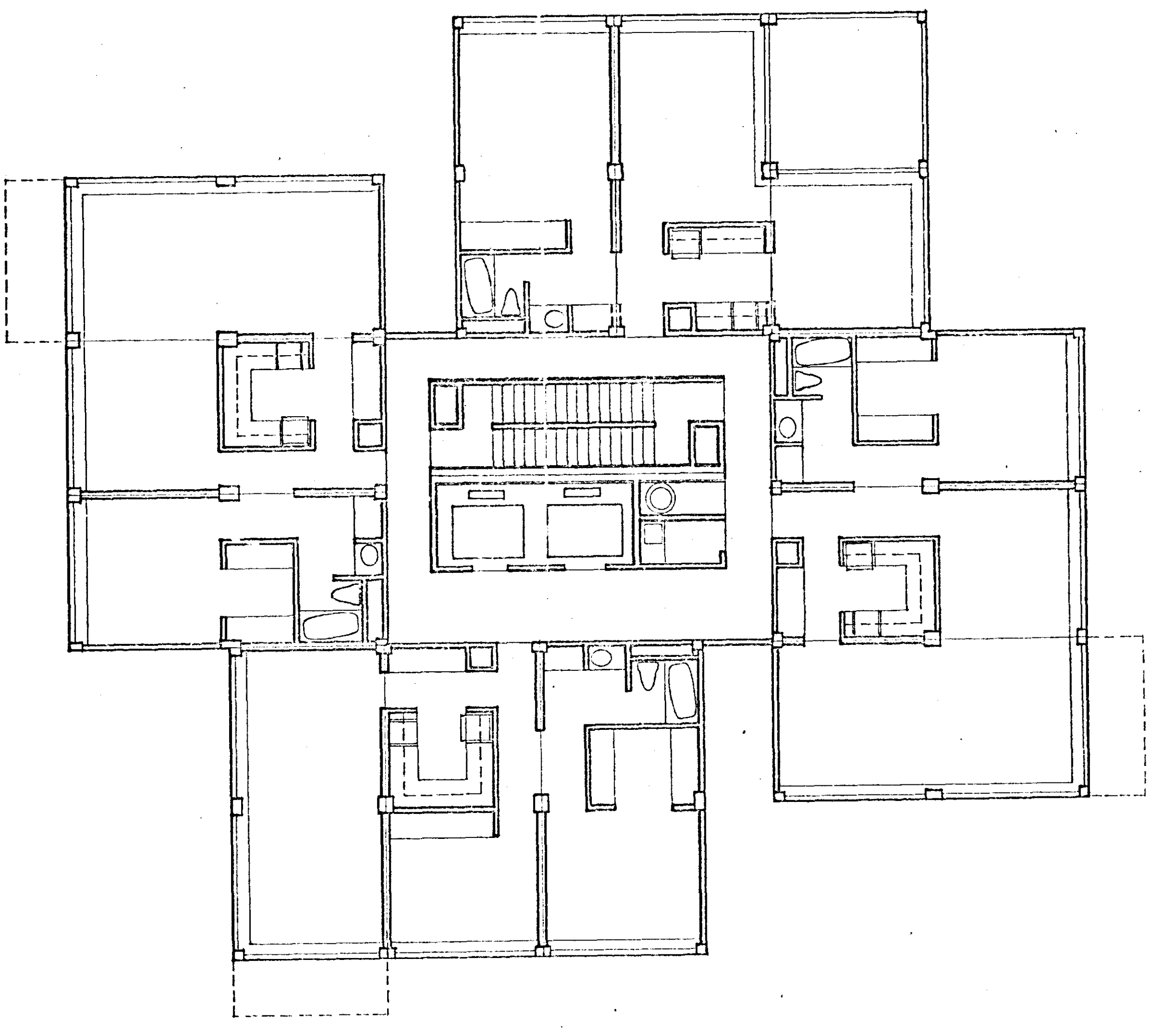
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI-FAMILY HIGH RISE



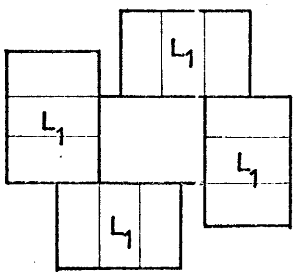
C:G 1:4.8

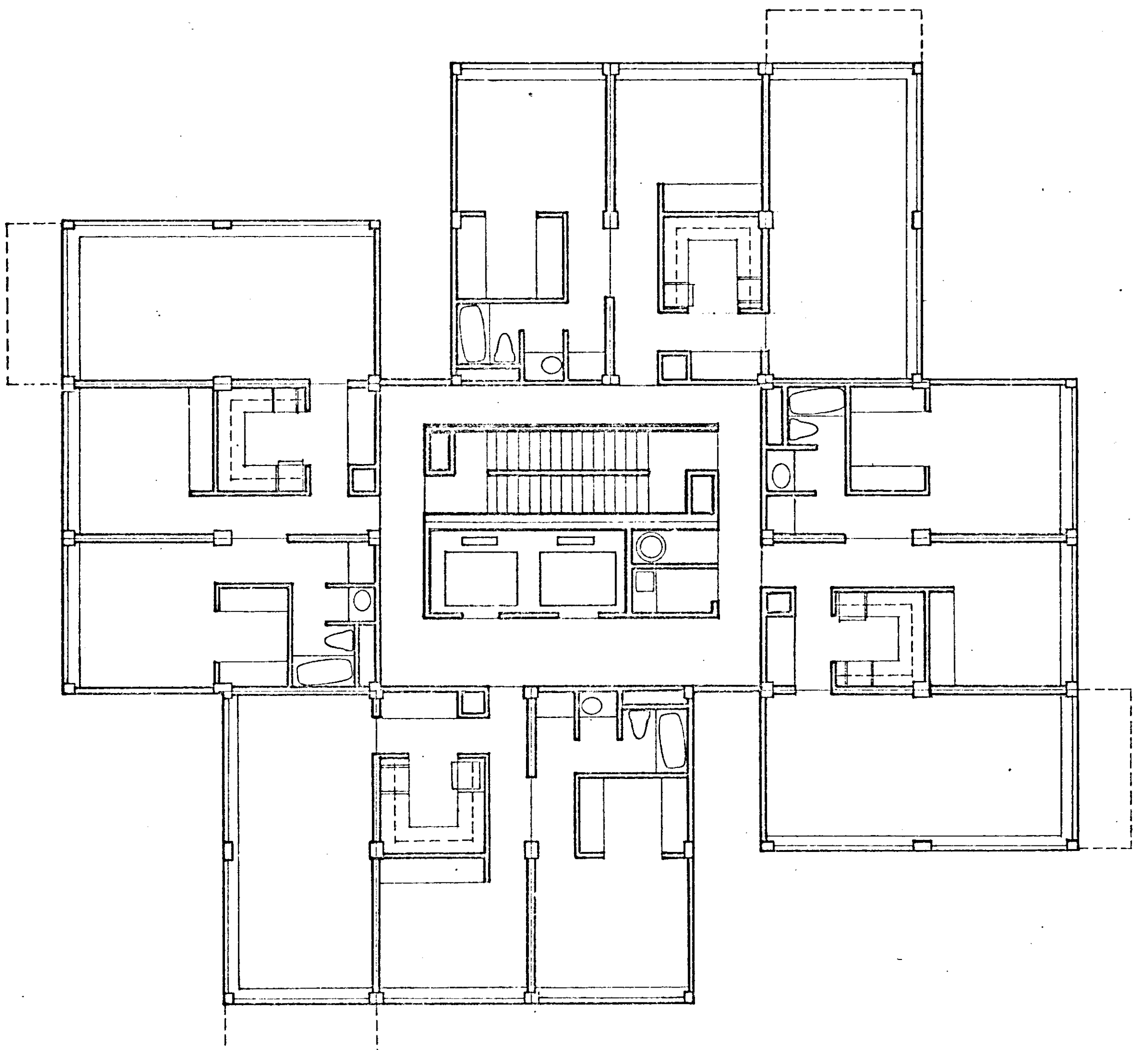
FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1'-0"

MULTI-FAMILY HIGH RISE

FIG. 56



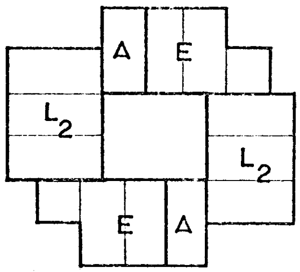



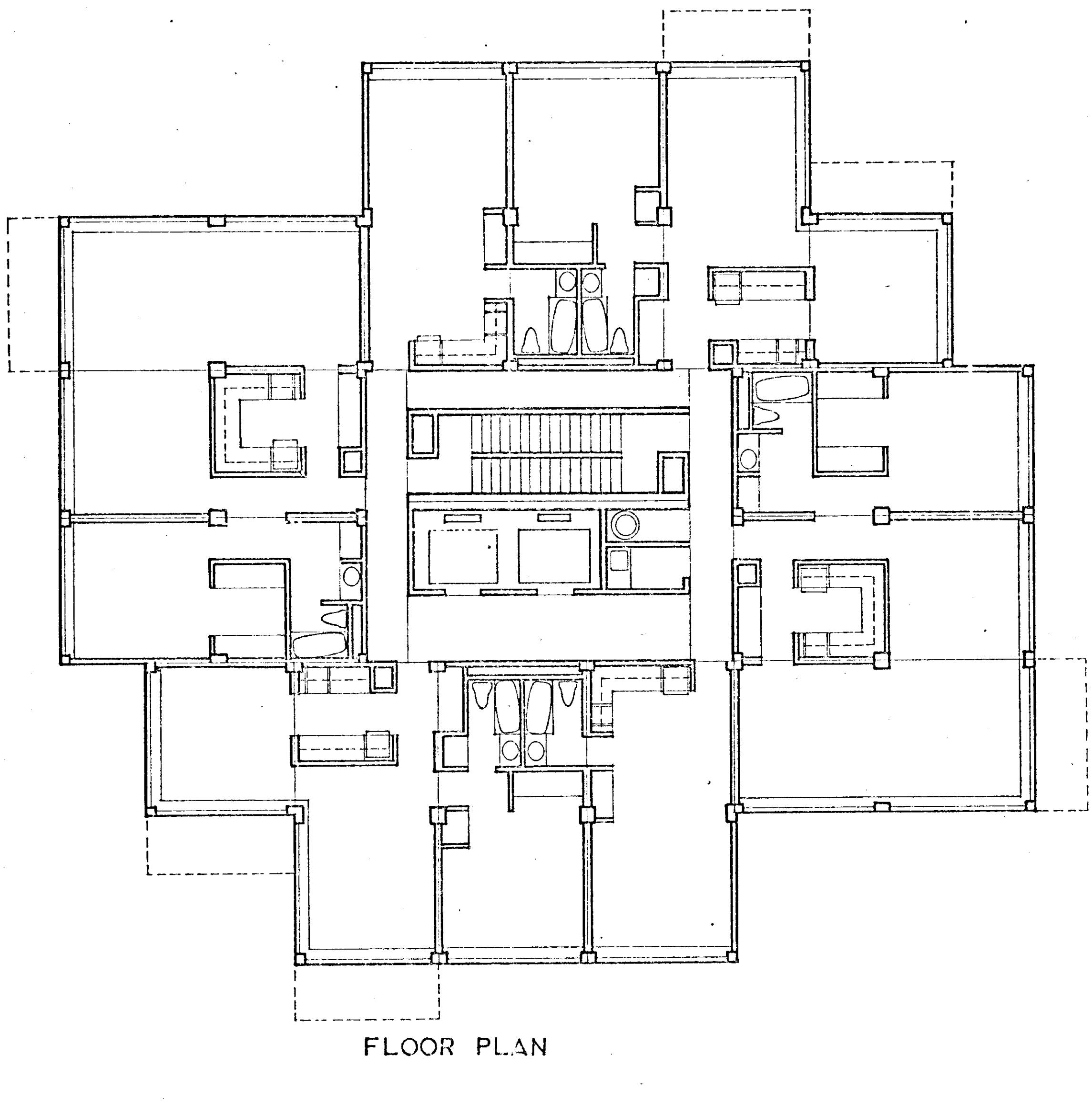
C.G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1'-0"

MULTI-FAMILY HIGH RISE



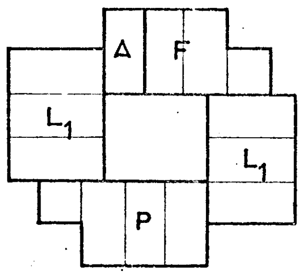



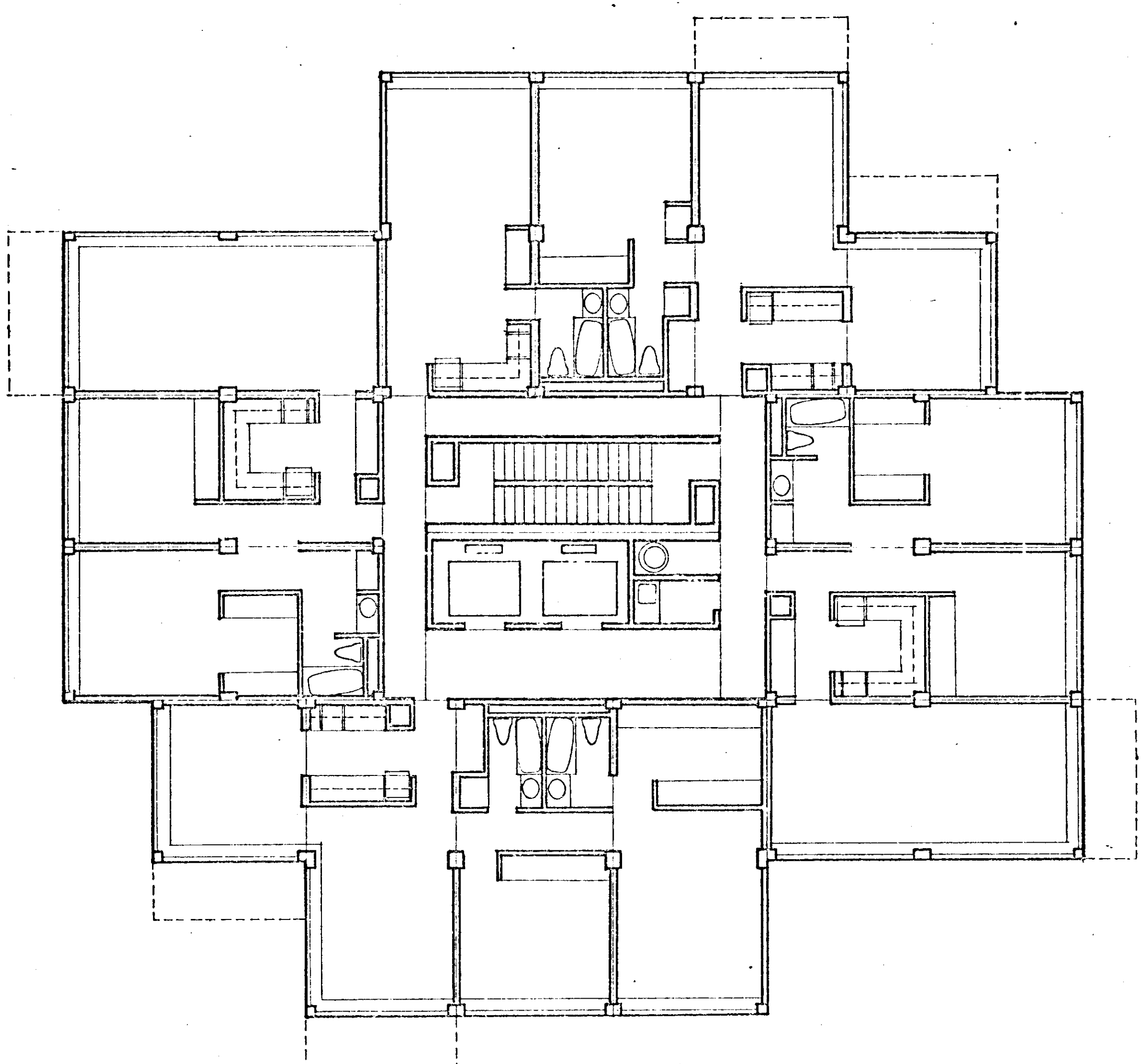
C : G 1: 4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = ′ - 0″

MULTI - FAMILY HIGH RISE



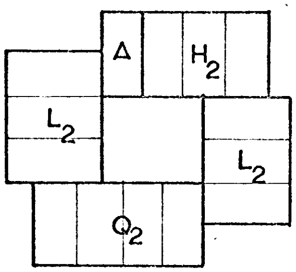



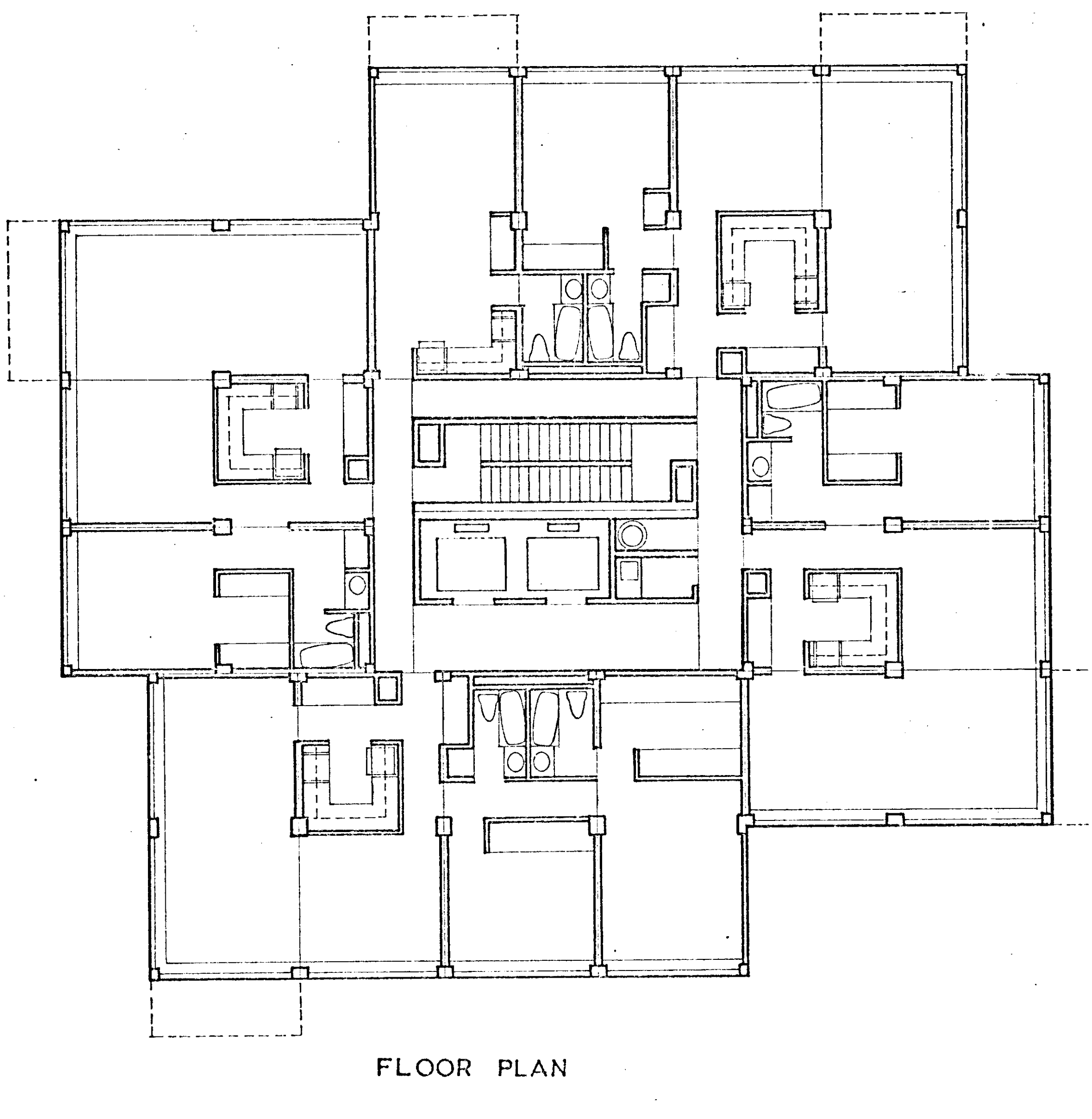
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0"

MULTI-FAMILY HIGH RISE



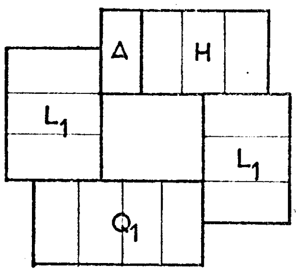



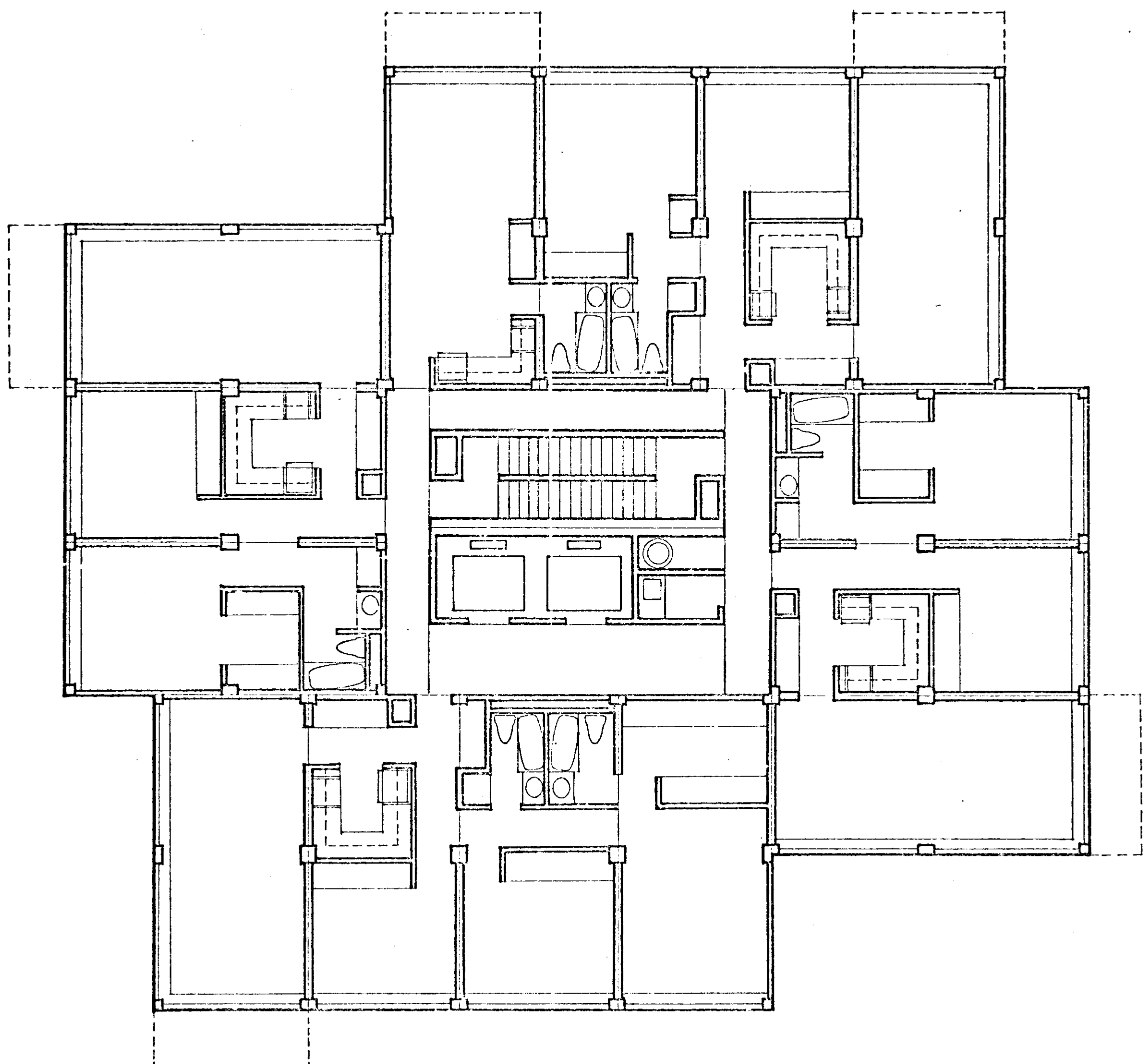
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

# MULTI-FAMILY HIGH RISE



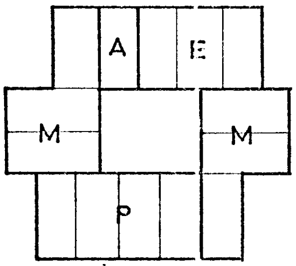



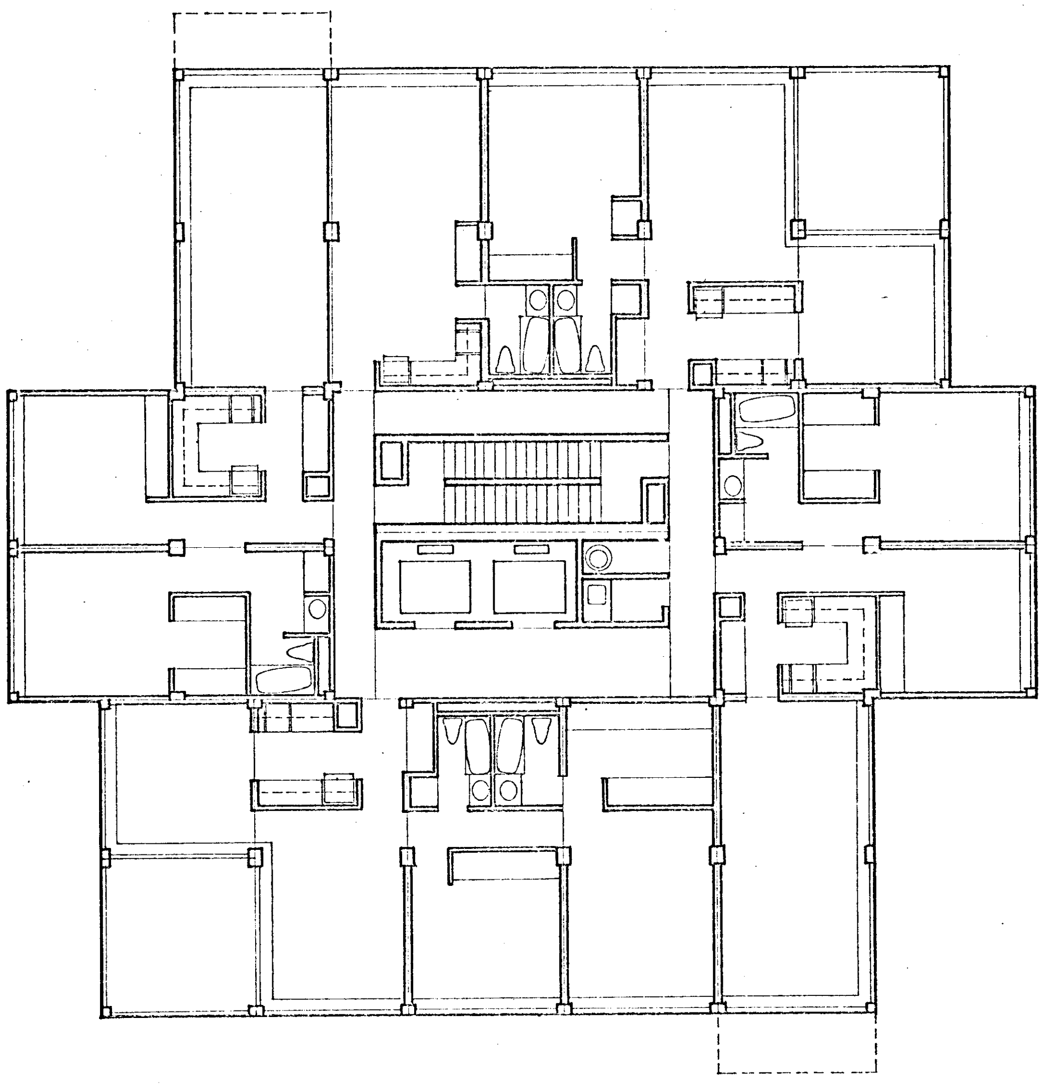
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

MULTI-FAMILY HIGH RISE



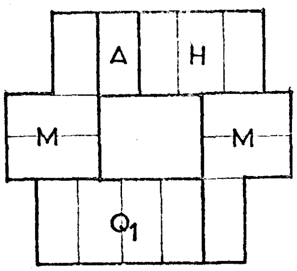



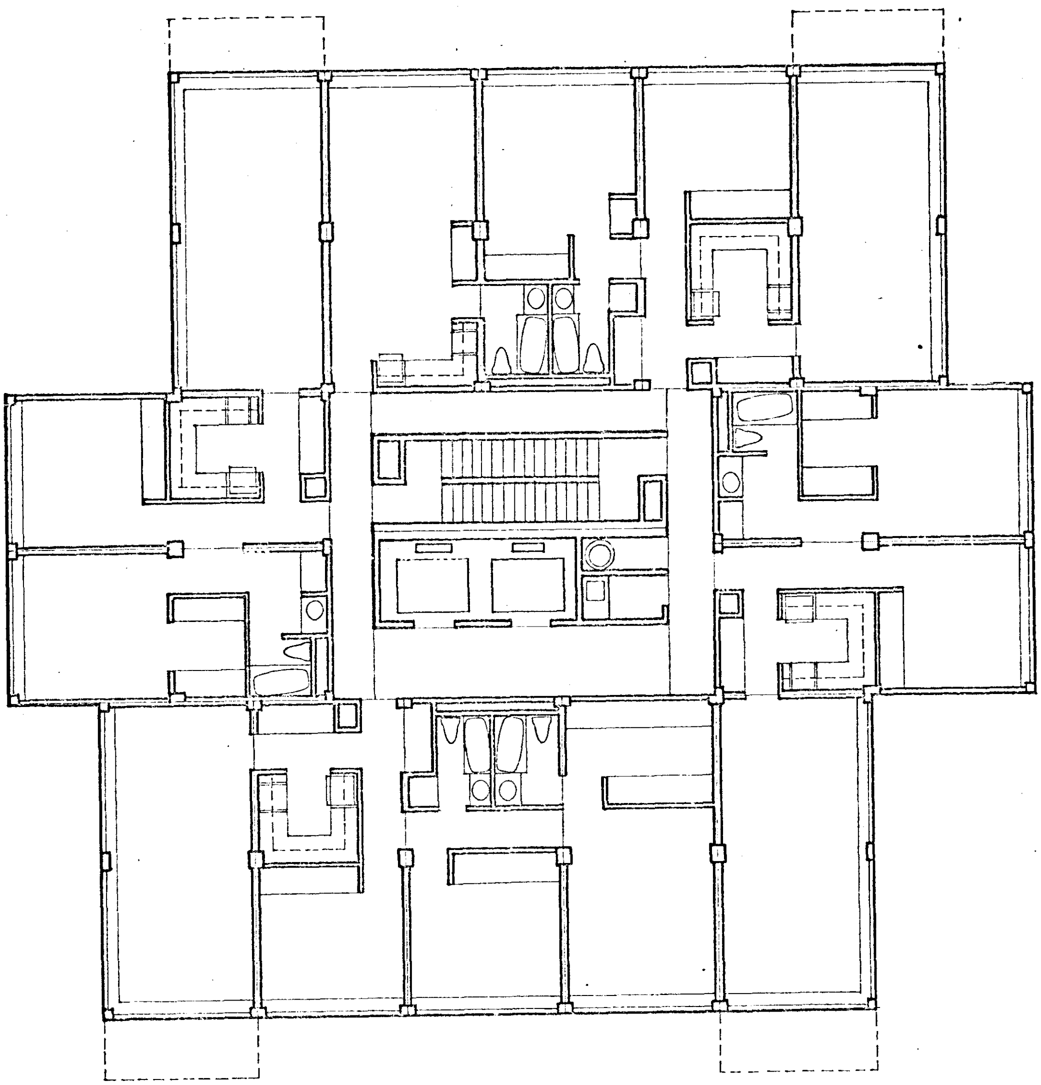
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

MULTI-FAMILY HIGH RISE



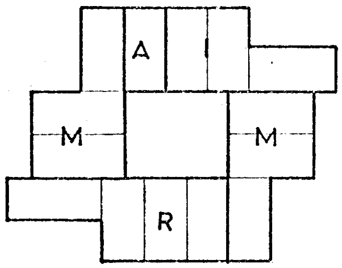



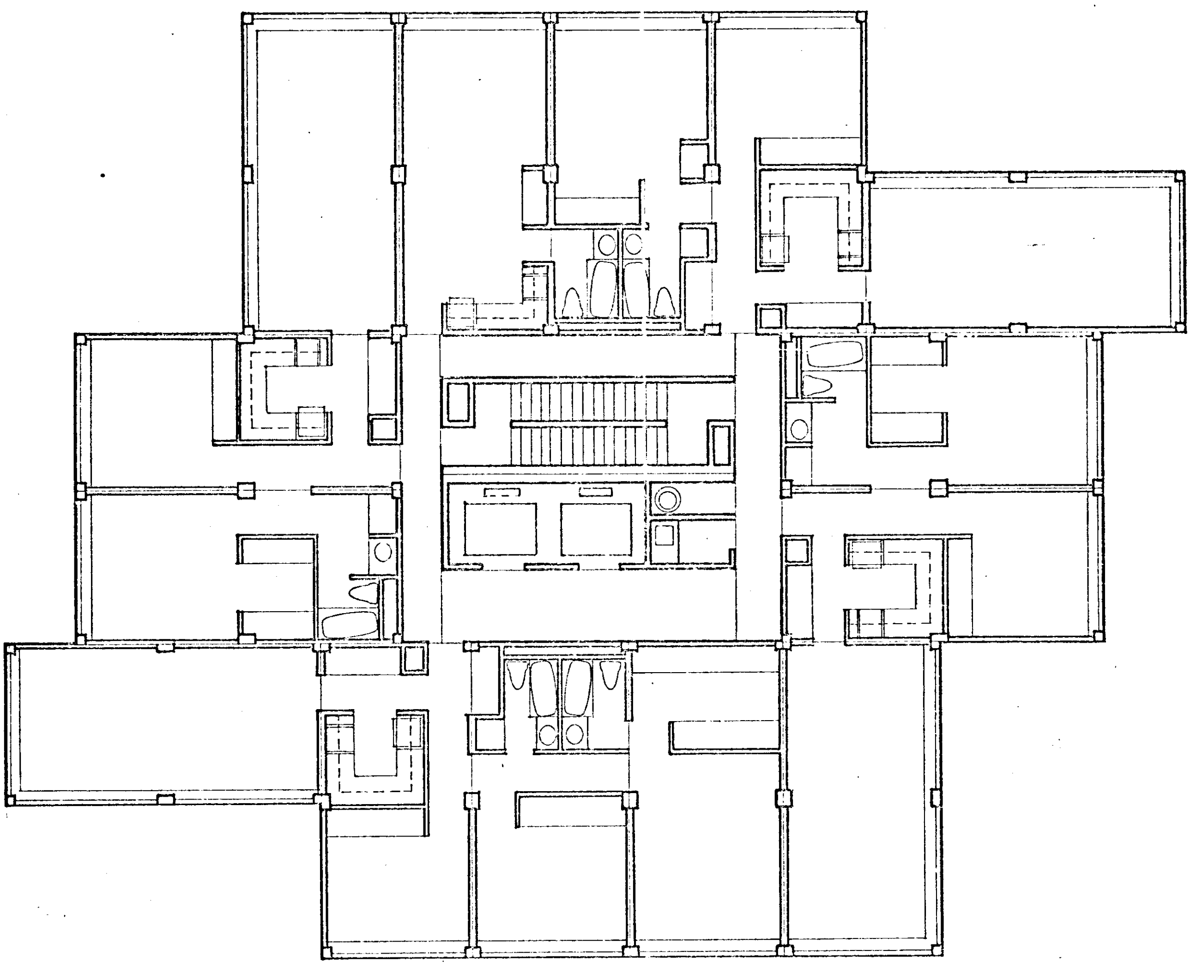
C : G 1;4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0"

MULTI-FAMILY HIGH RISE



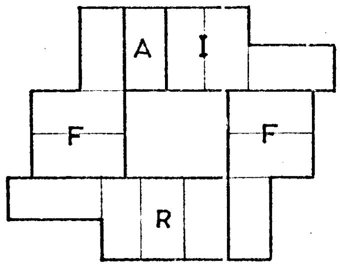
C : G 1:4.8

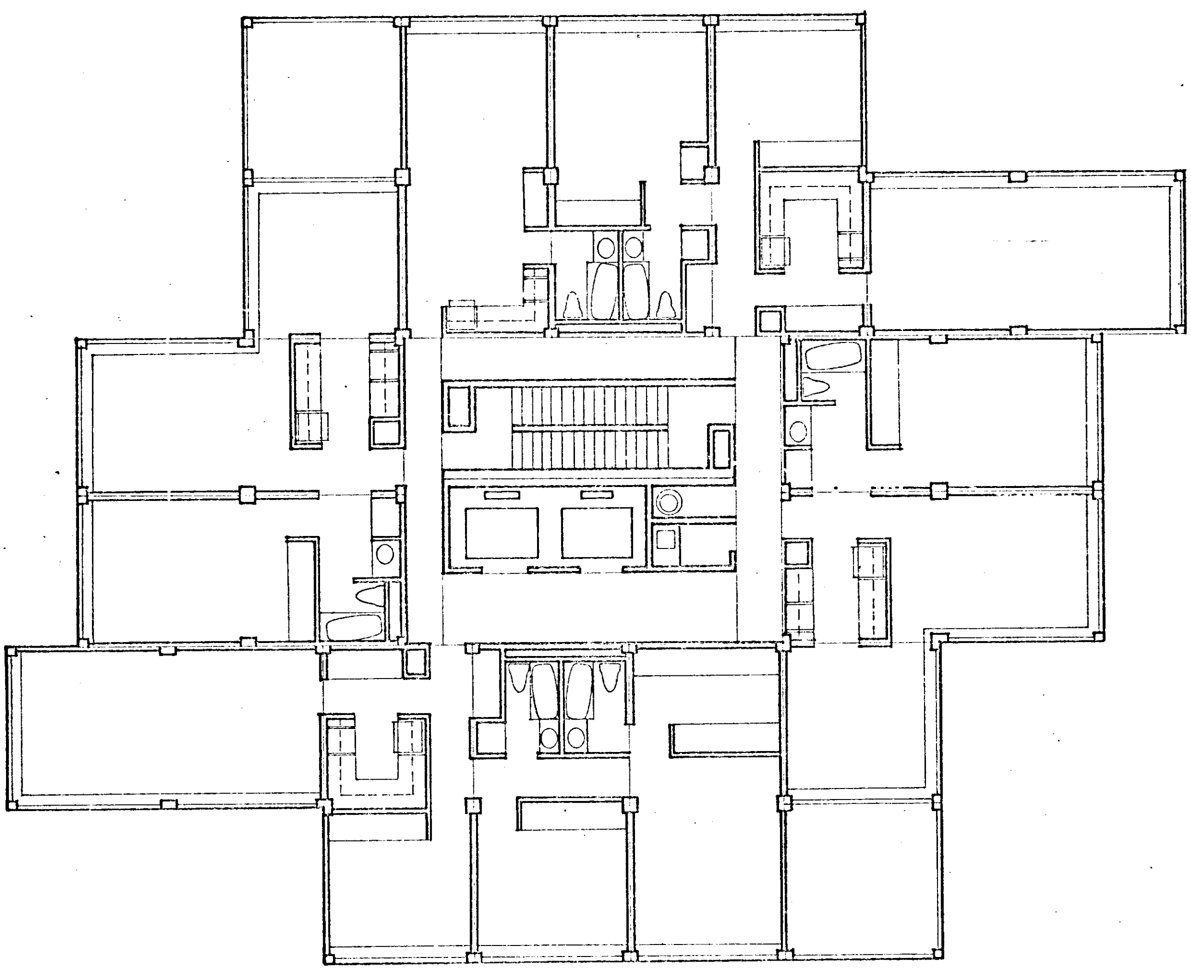
FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0"

MULTI-FAMILY HIGH RISE

FIG.64



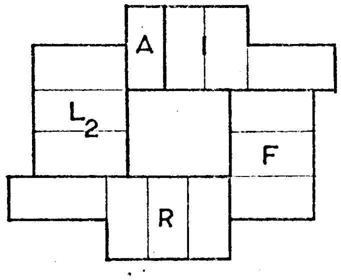



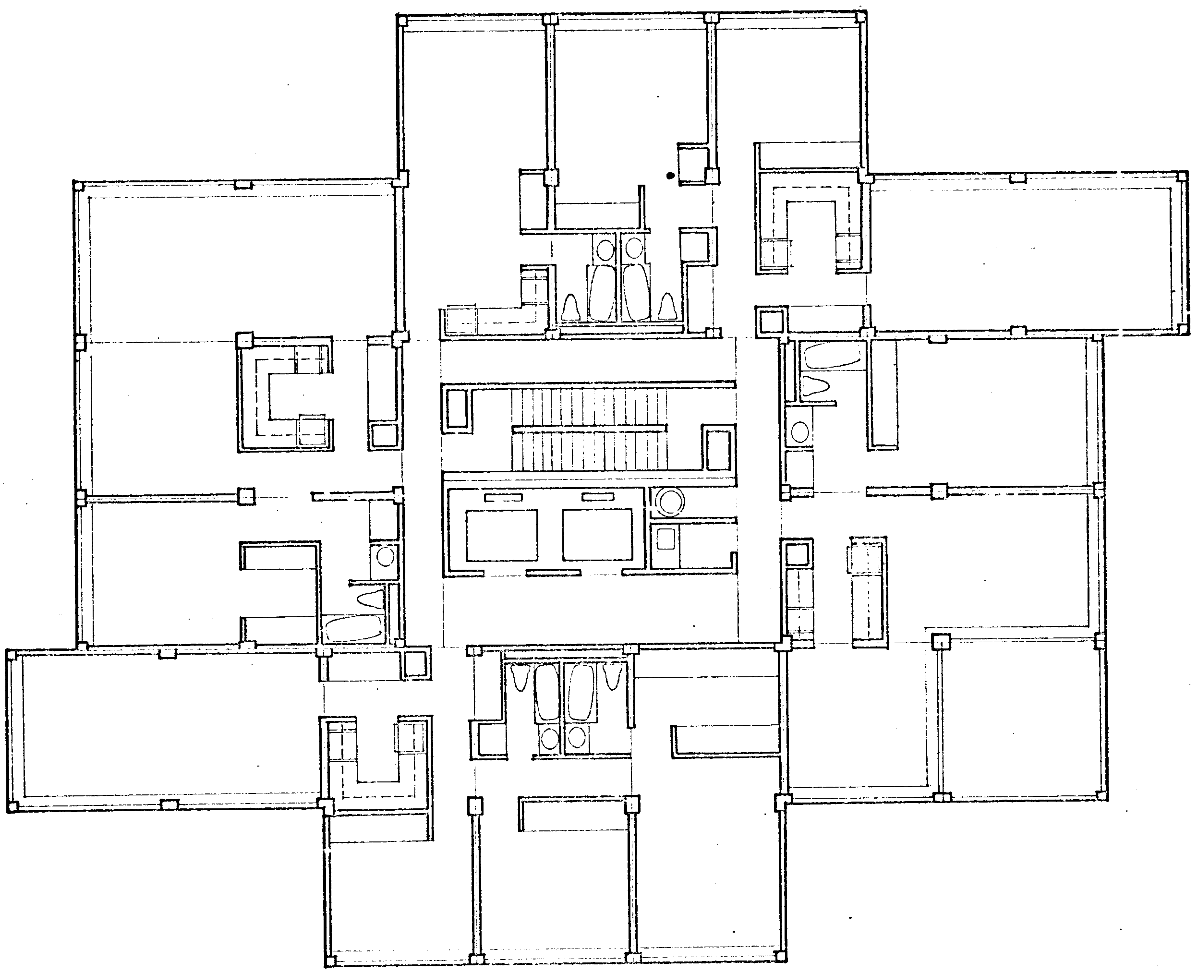
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = ′ - 0″

MULTI-FAMILY HIGH RISE



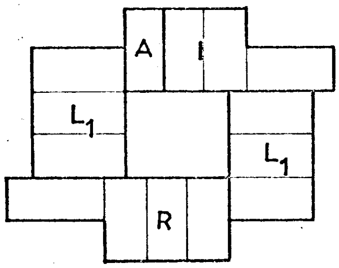



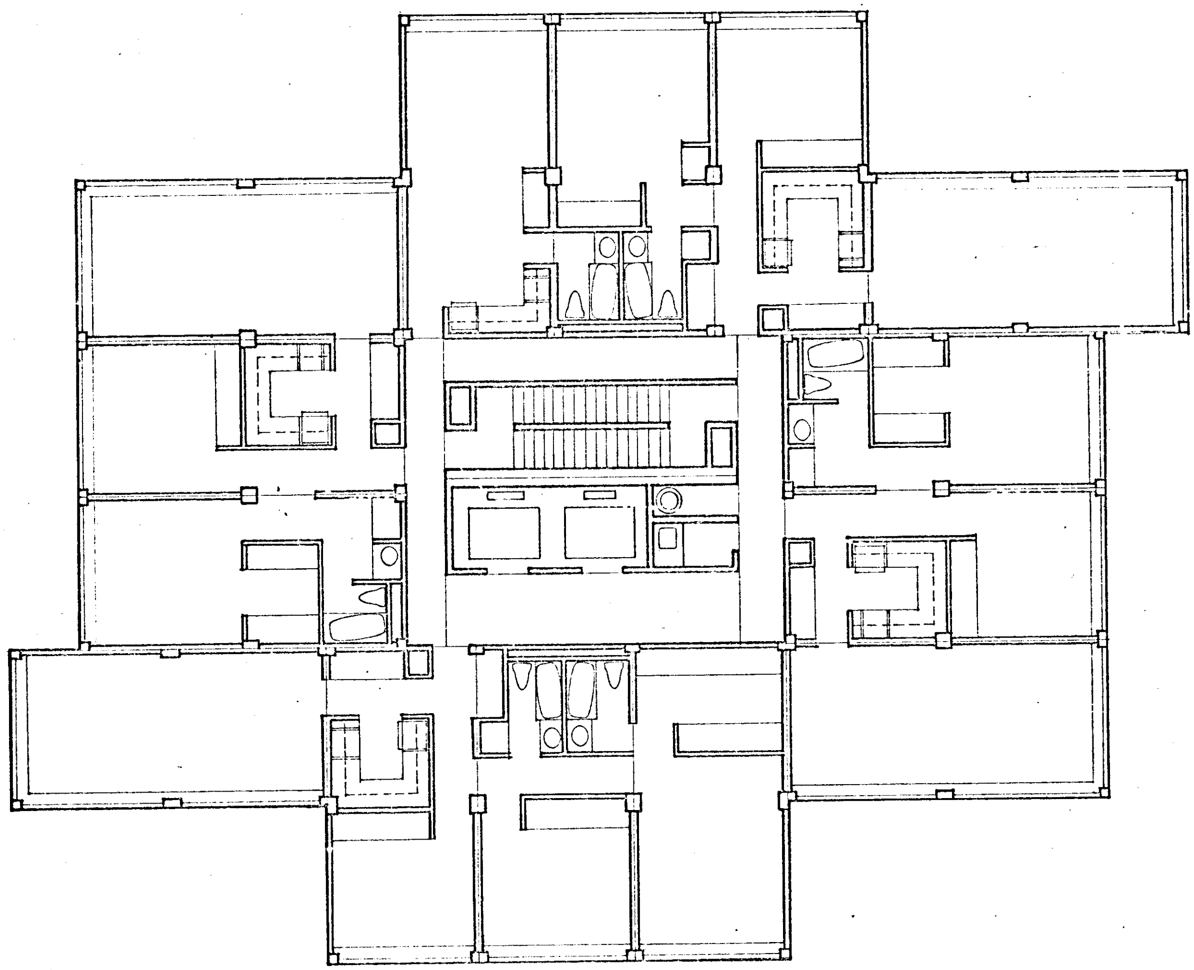
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

MULTI-FAMILY HIGH RISE



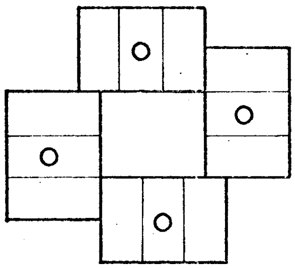
C : G 1 : 4.8

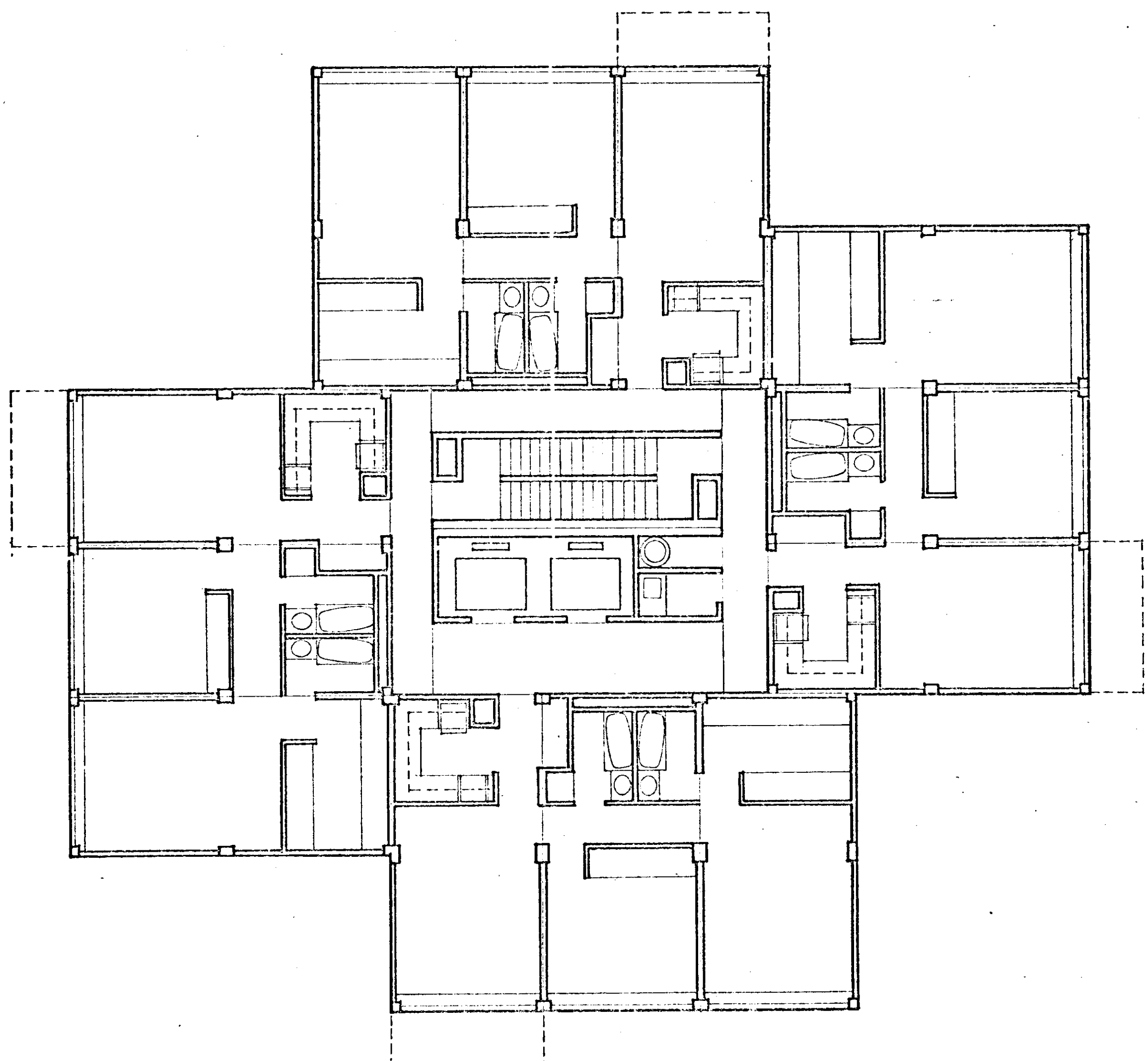
FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0"

MULTI - FAMILY HIGH RISE

FIG.67





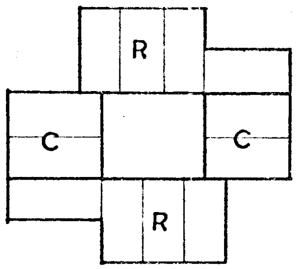
C : G 1:4.8

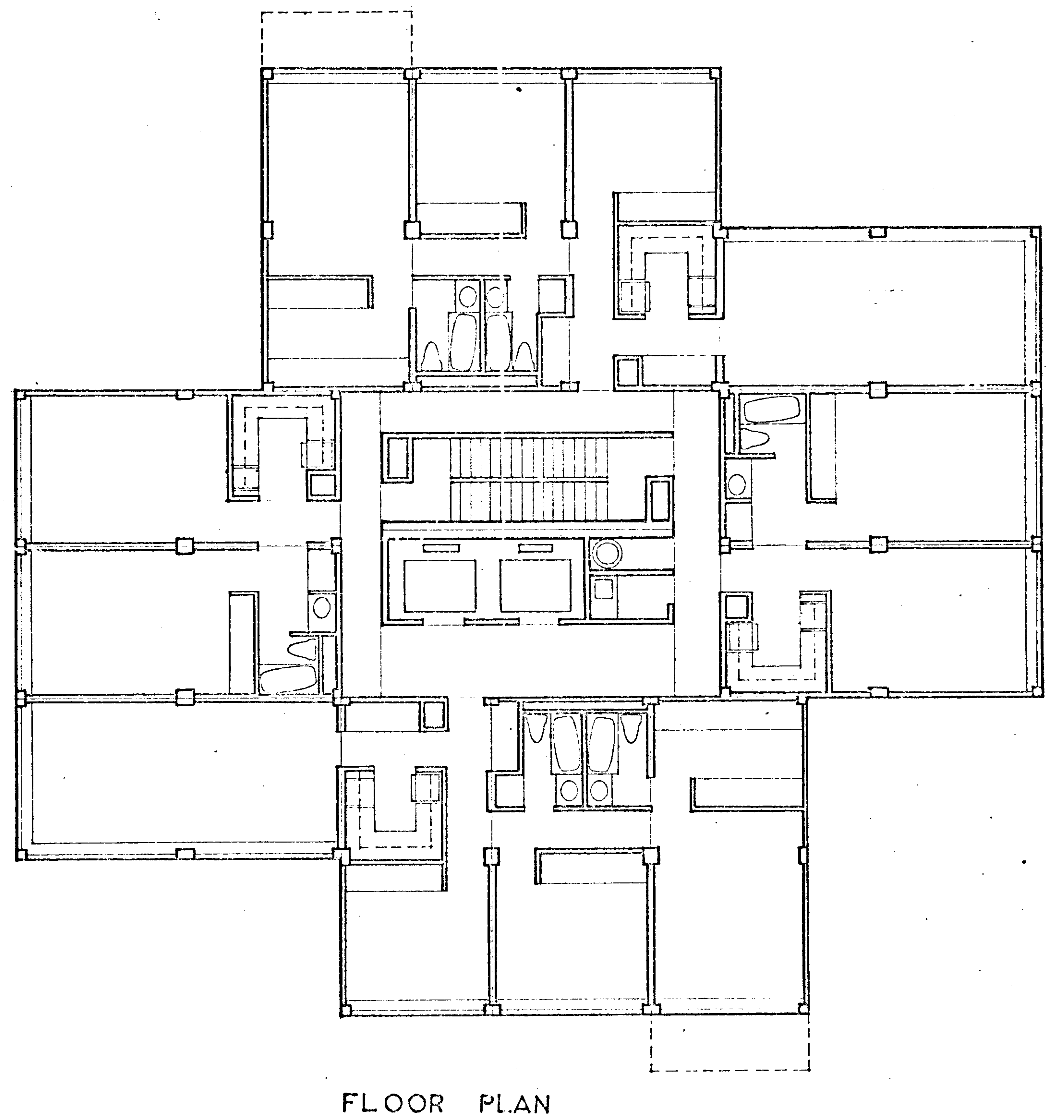
FLOOR PLAN

SCALE $\frac{1}{16}$" = 1' - 0"

MULTI - FAMILY HIGH RISE

FIG. 68



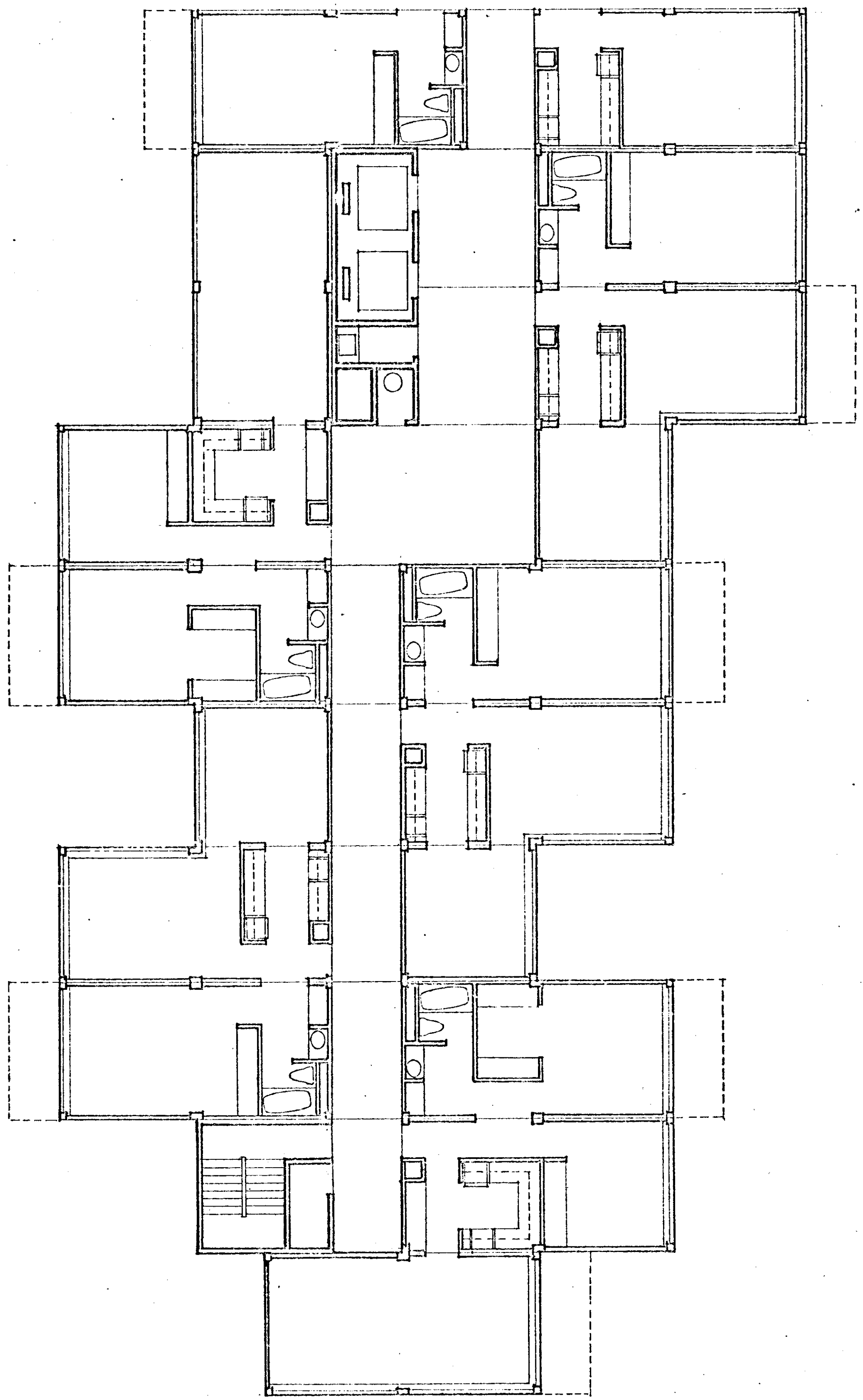
C : G 1:4.8

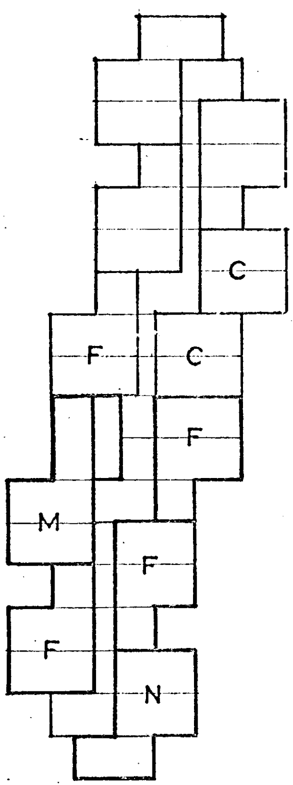
FLOOR PLAN

SCALE $\frac{1}{16}$" = 1' - 0"

MULTI-FAMILY HIGH RISE

FIG. 69





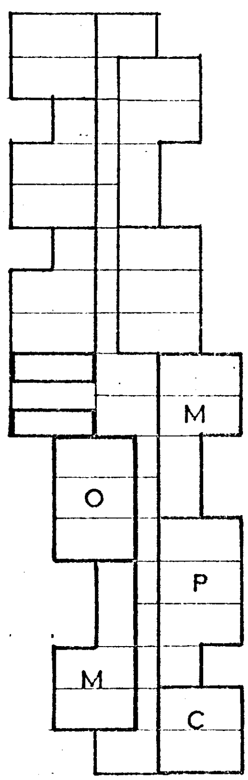

C : G 1 : 4

FLOOR PLAN

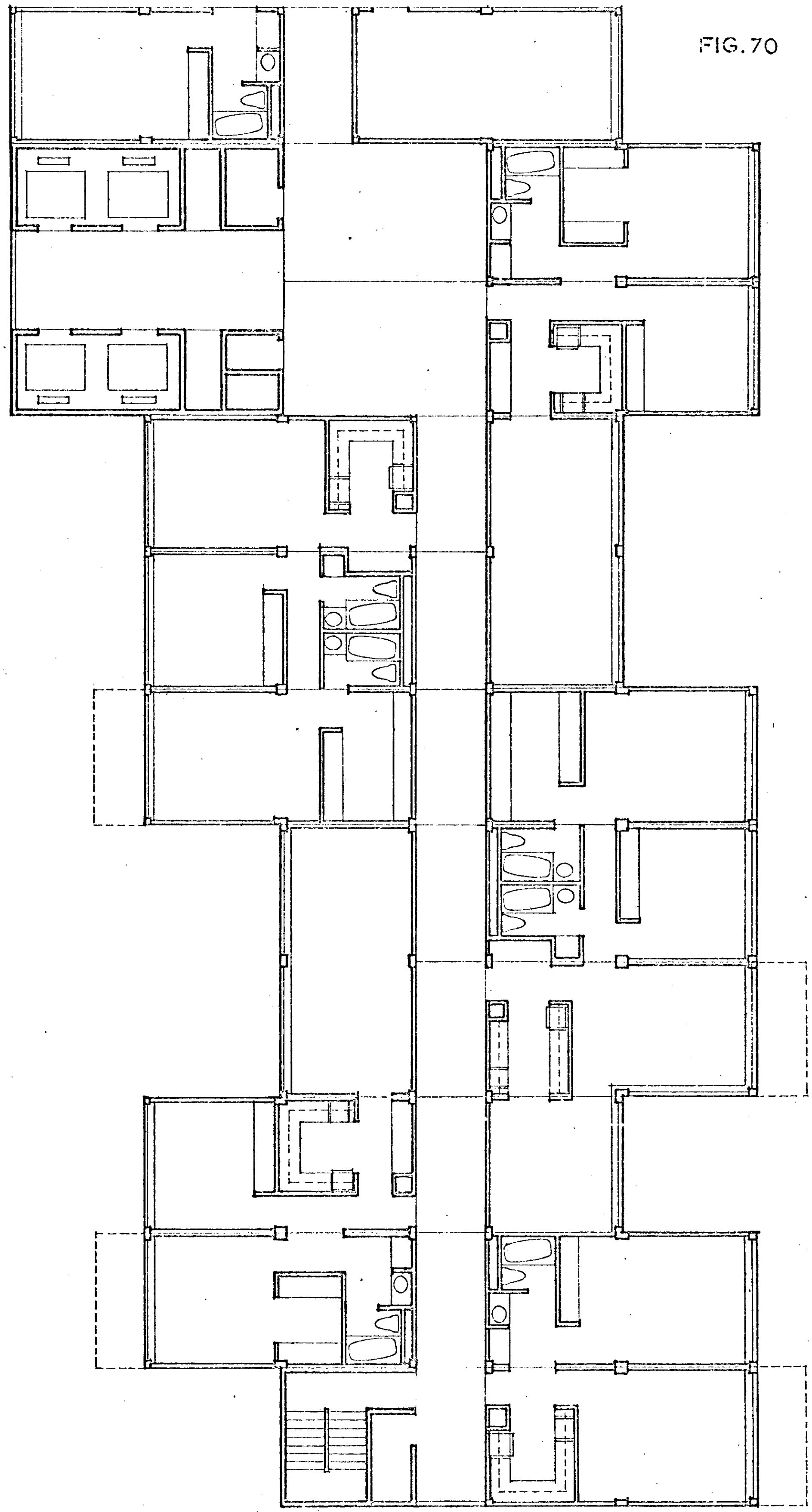
SCALE $\frac{1}{16}''$ = 1' - 0"

MULTI - FAMILY HIGH RISE

FIG. 70



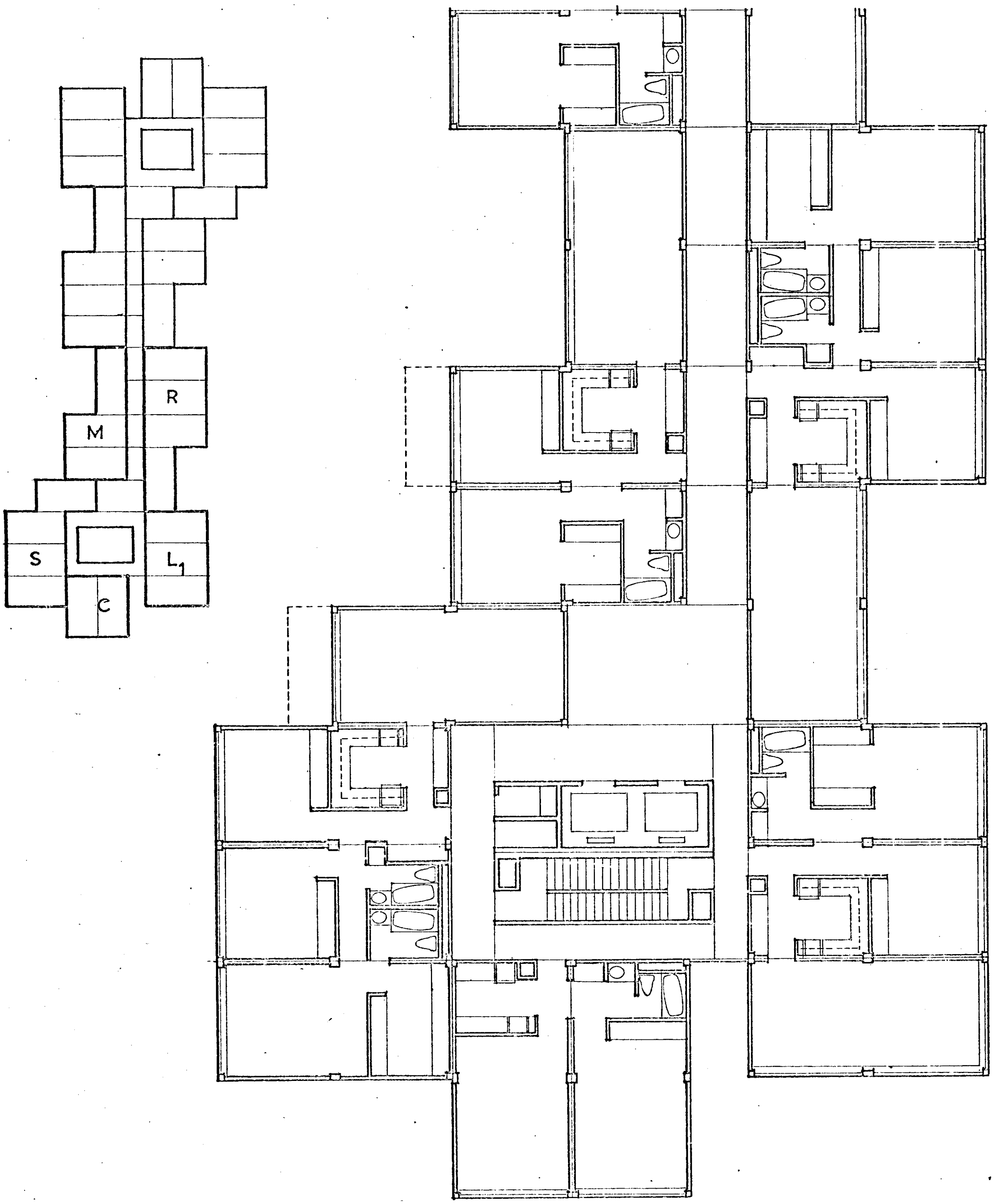

C : G 1 : 3.2



FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI - FAMILY HIGH RISE

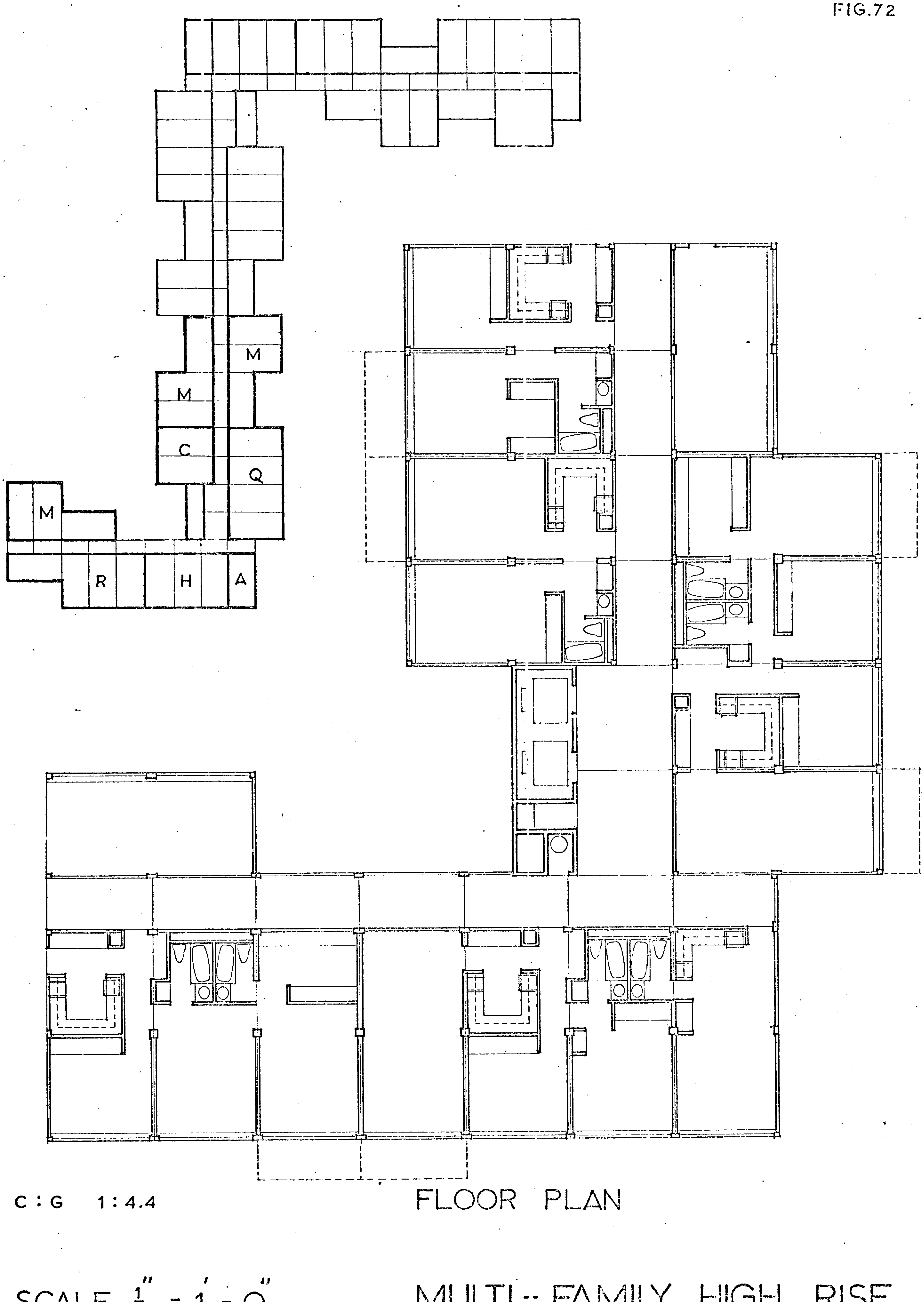



C : G 1:35

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1'-0''$

MULTI - FAMILY HIGH RISE



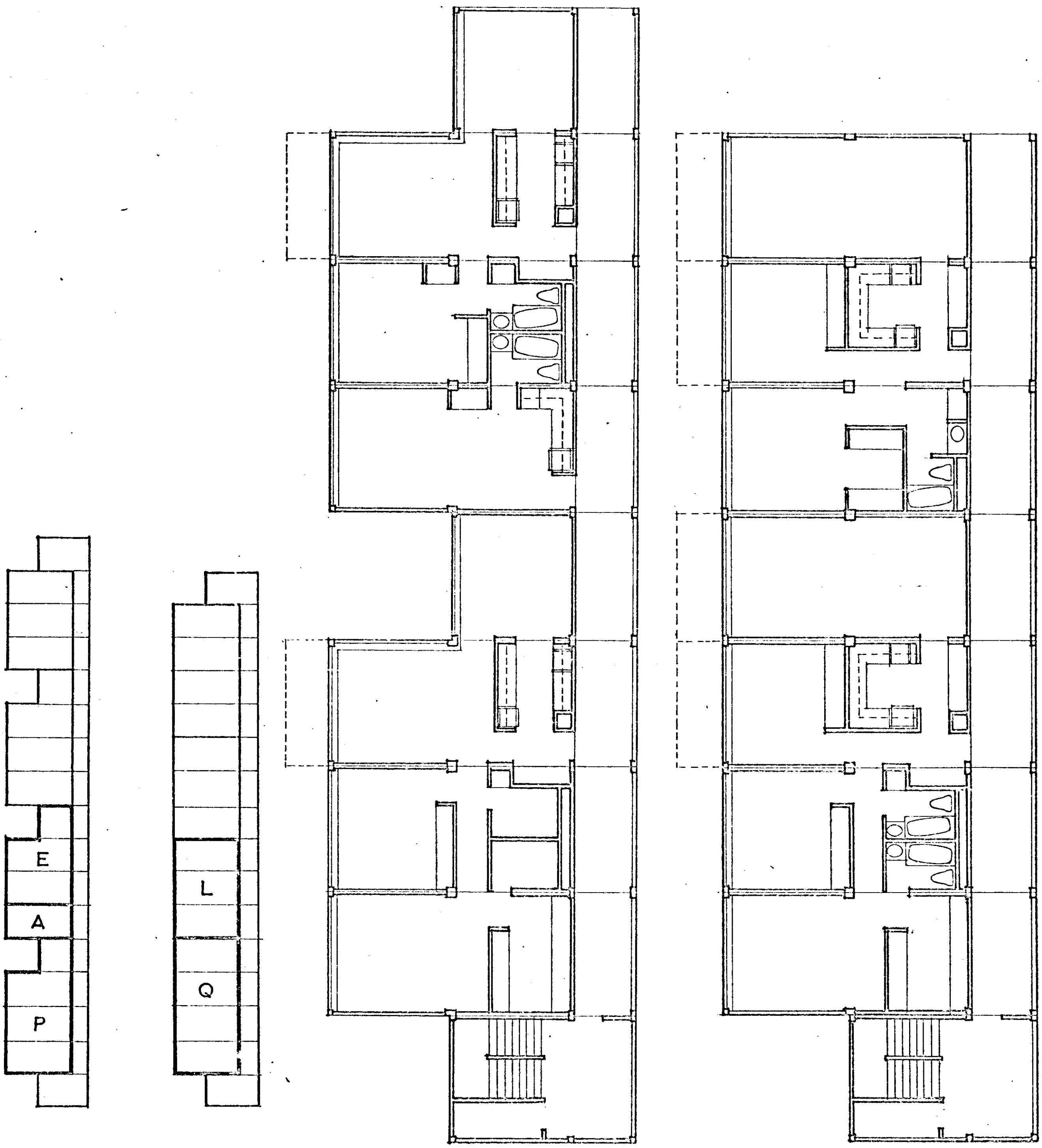

C : G 1 : 4.4

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1'-0"

MULTI-- FAMILY HIGH RISE

FIG. 73



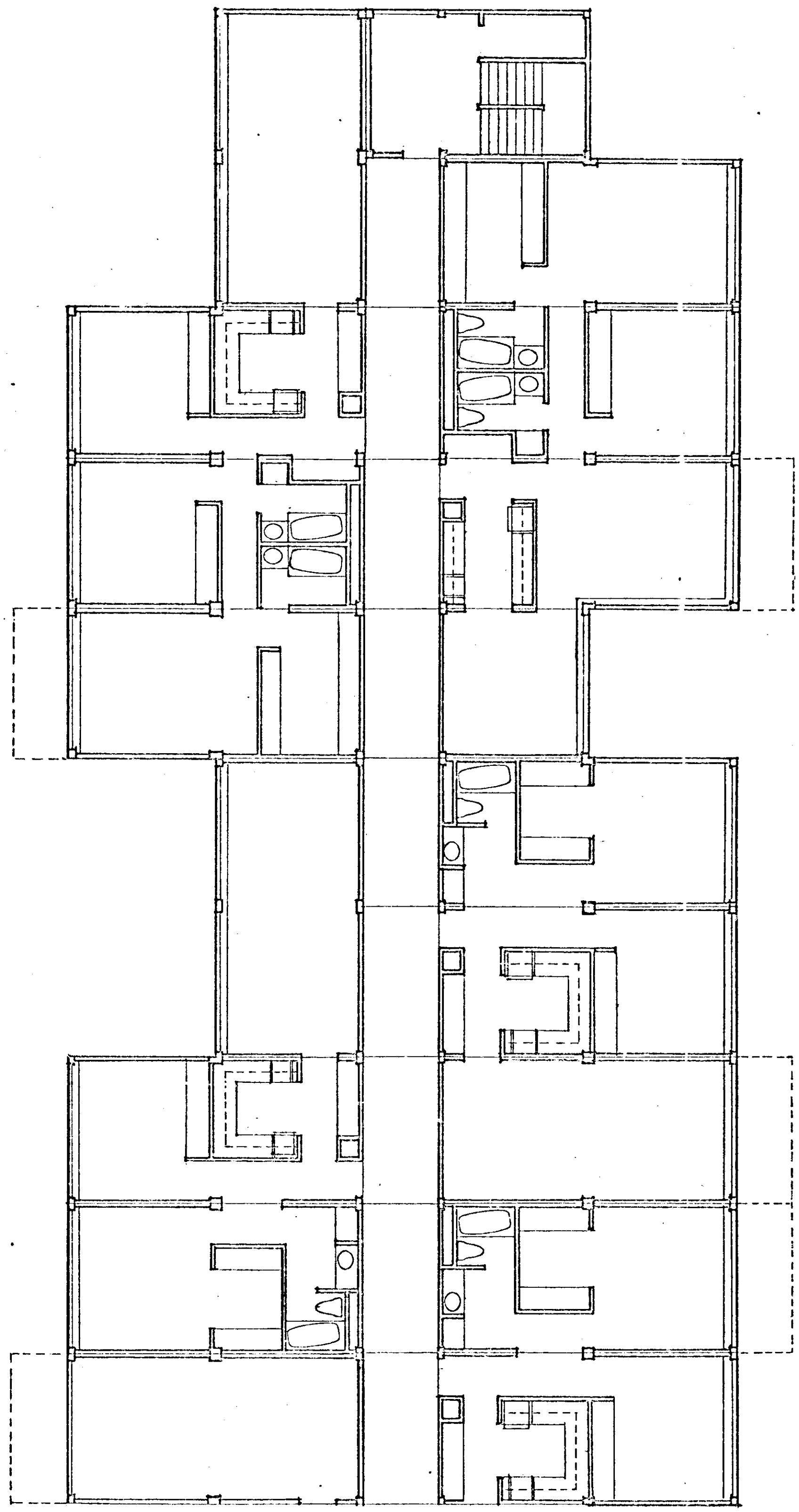

C : G 1 : 2.8

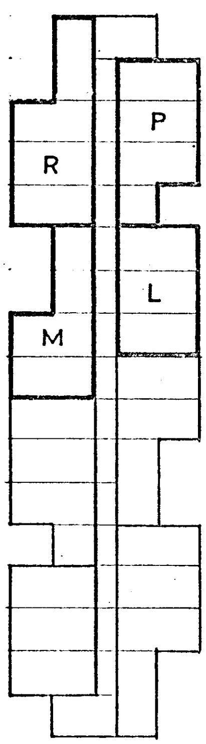
FLOOR PLAN

SCALE 1/16" = ' - 0"

MULTI-FAMILY LOW RISE

FIG. 74





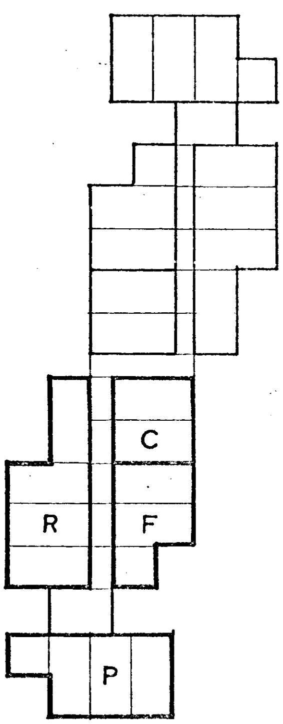

C : G 1: 5.1

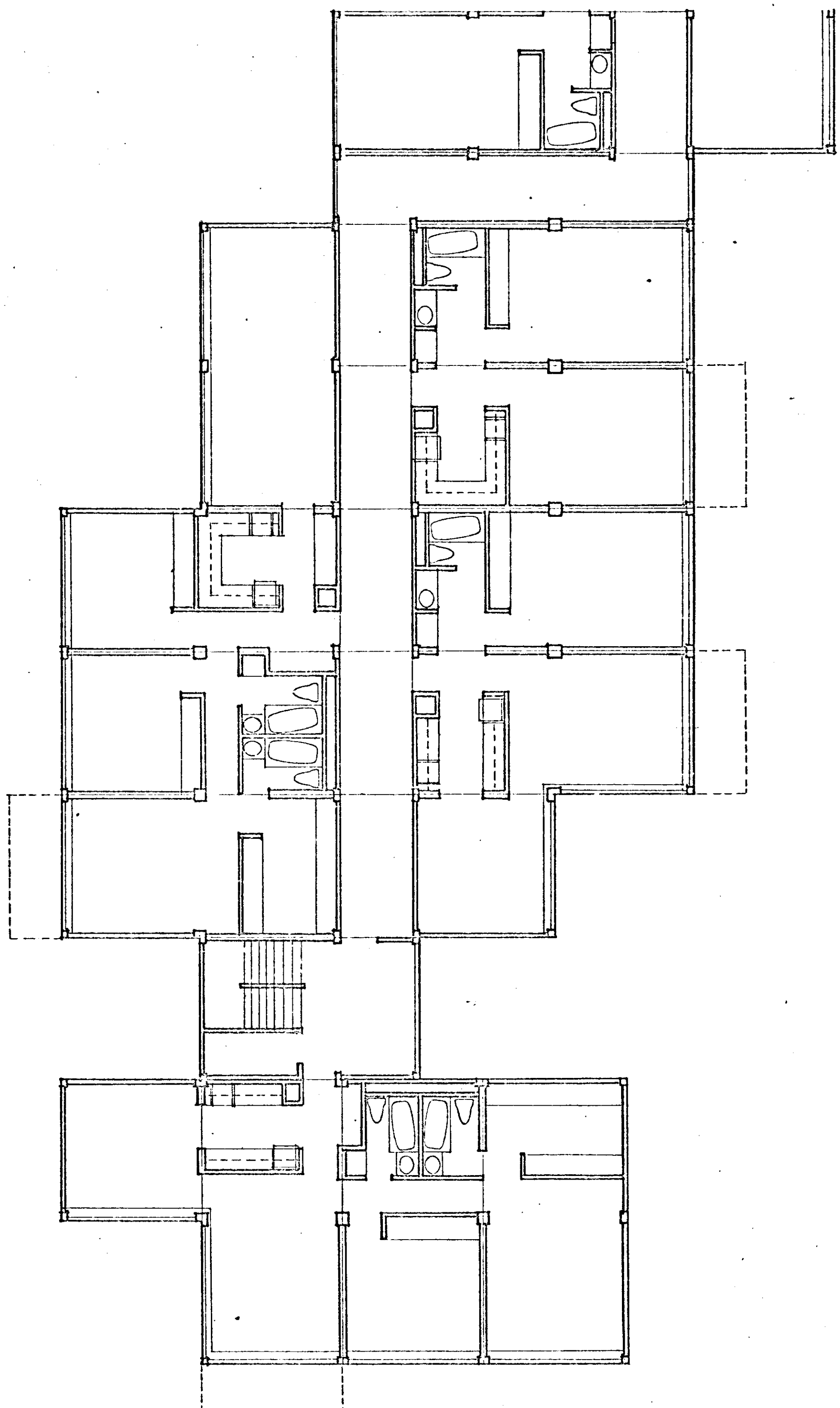
FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

MULTI FAMILY LOW RISE

FIG. 75



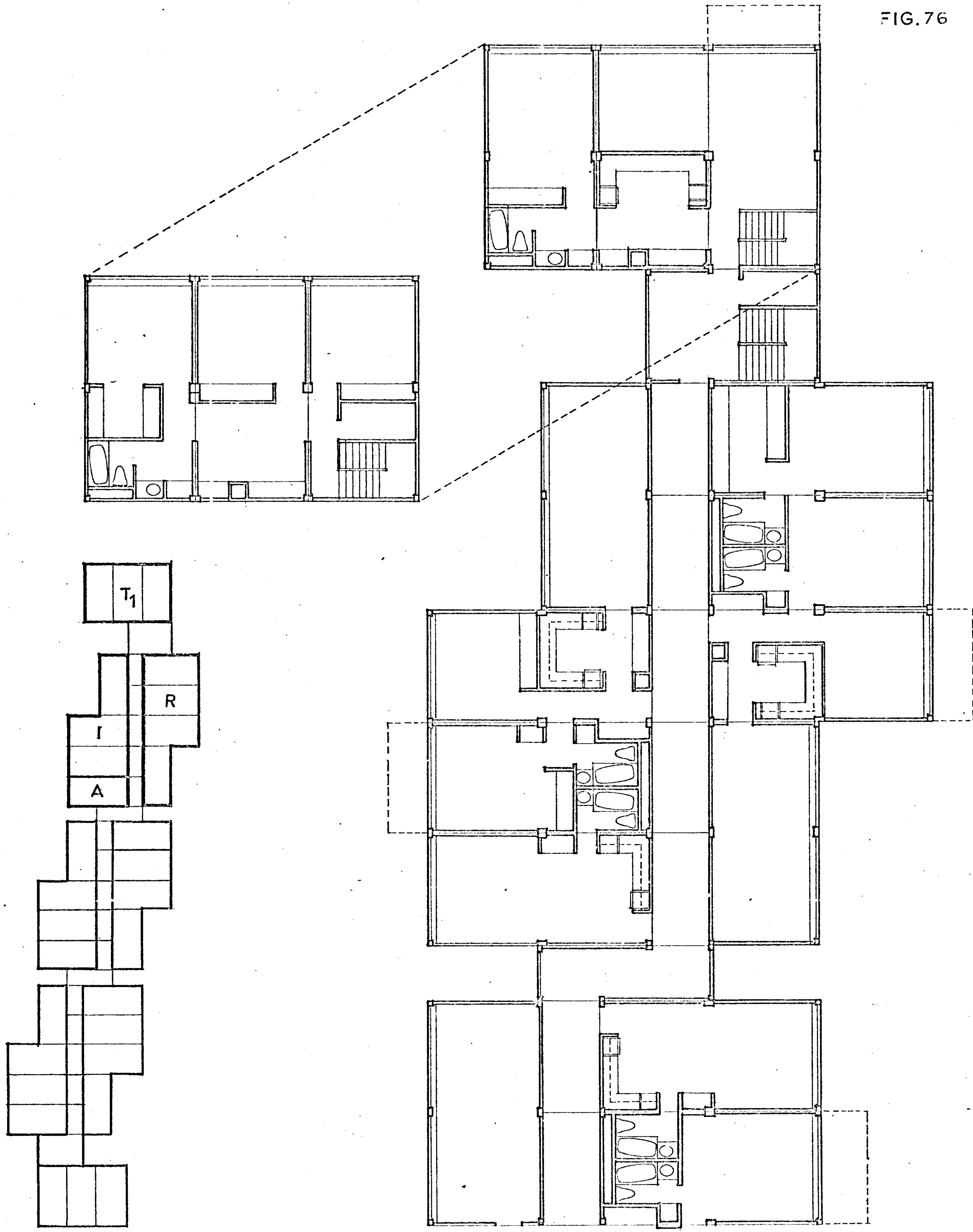
C : G 1:4.8

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI - FAMILY LOW RISE

FIG.76



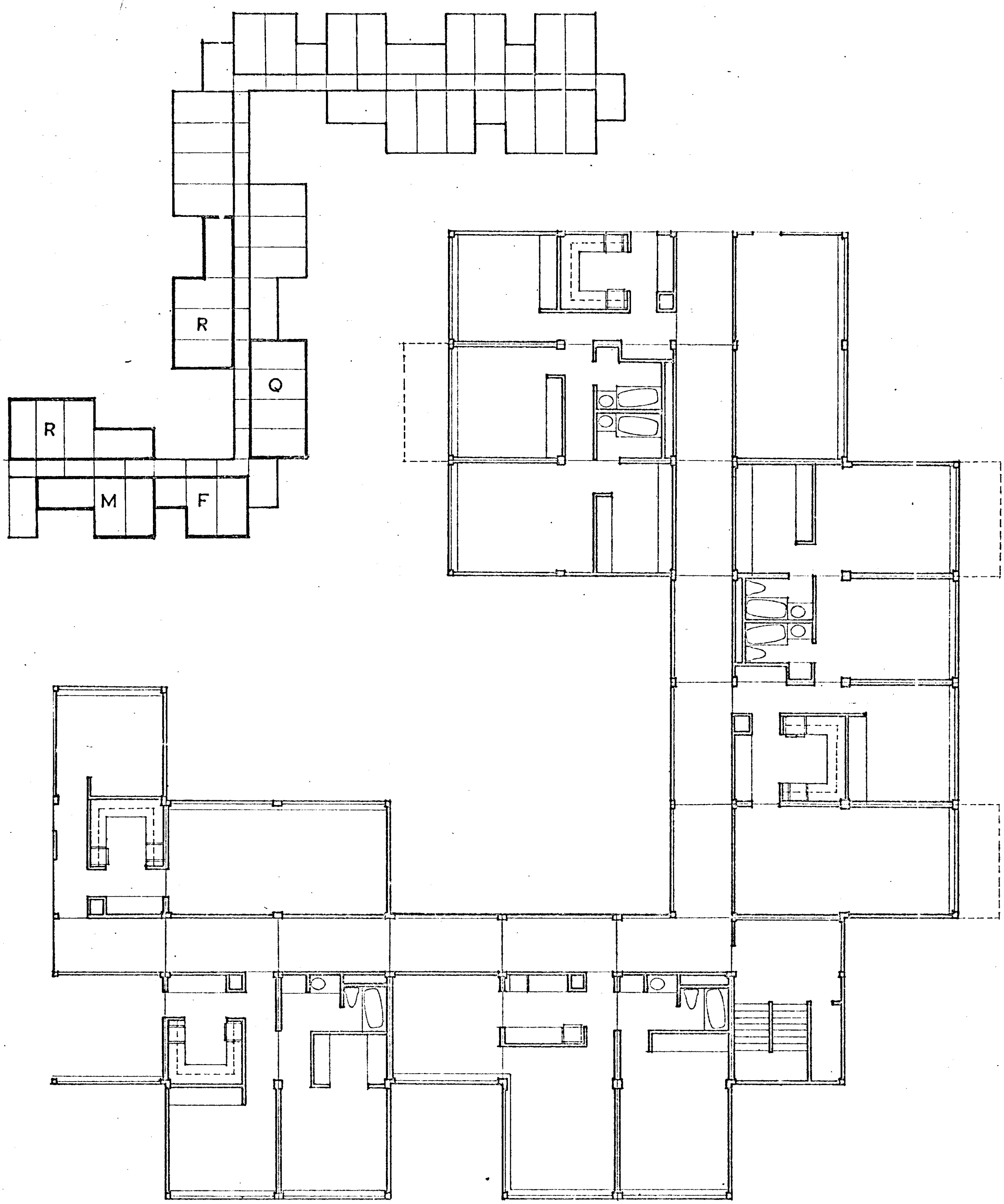

C : G 1:4.6

FLOOR PLAN

SCALE $\frac{1}{16}'' = 1' - 0''$

MULTI - FAMILY LOW RISE

FIG.77



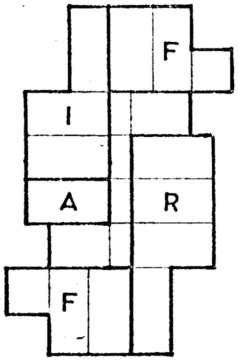

C : G 1:4.2

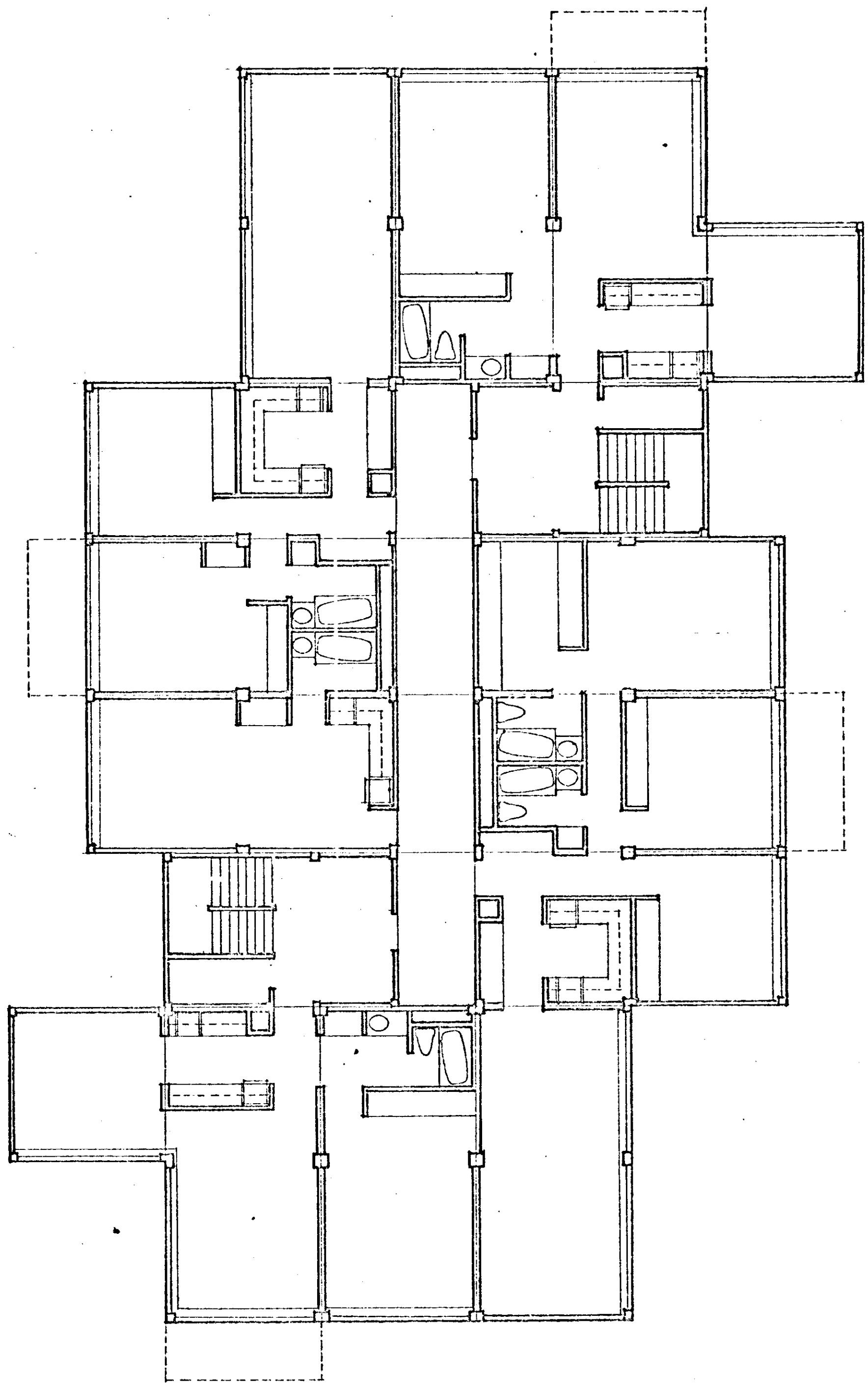
FLOOR PLAN

SCALE $\frac{1''}{16}$ = 1' - 0''

MULTI - FAMILY LOW RISE

FIG.78



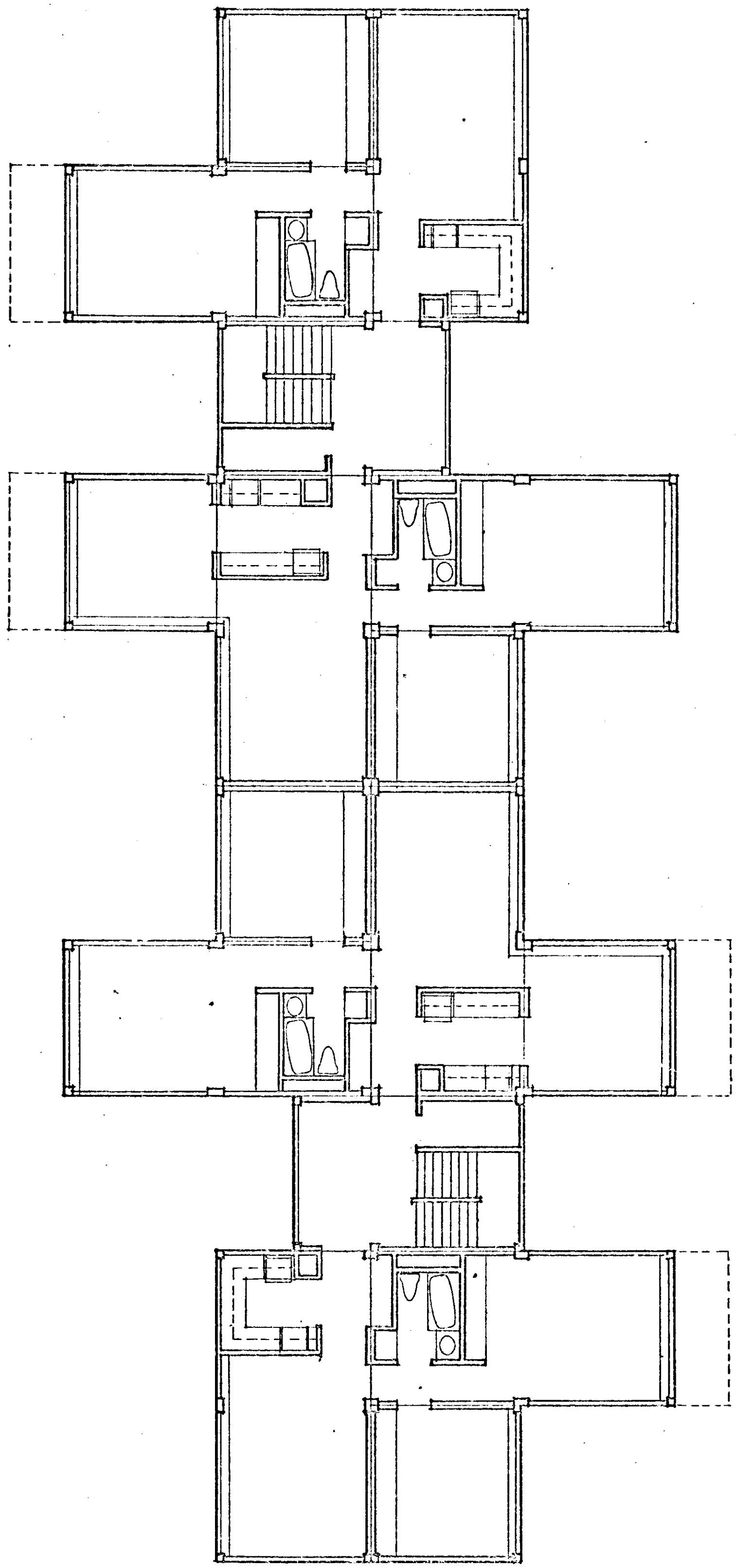



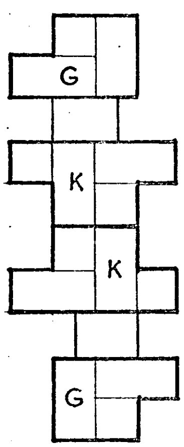
C : G 1 : 5.2

FLOOR PLAN

SCALE $\frac{1}{16}''$ = 1' - 0''

MULTI-FAMILY LOW RISE





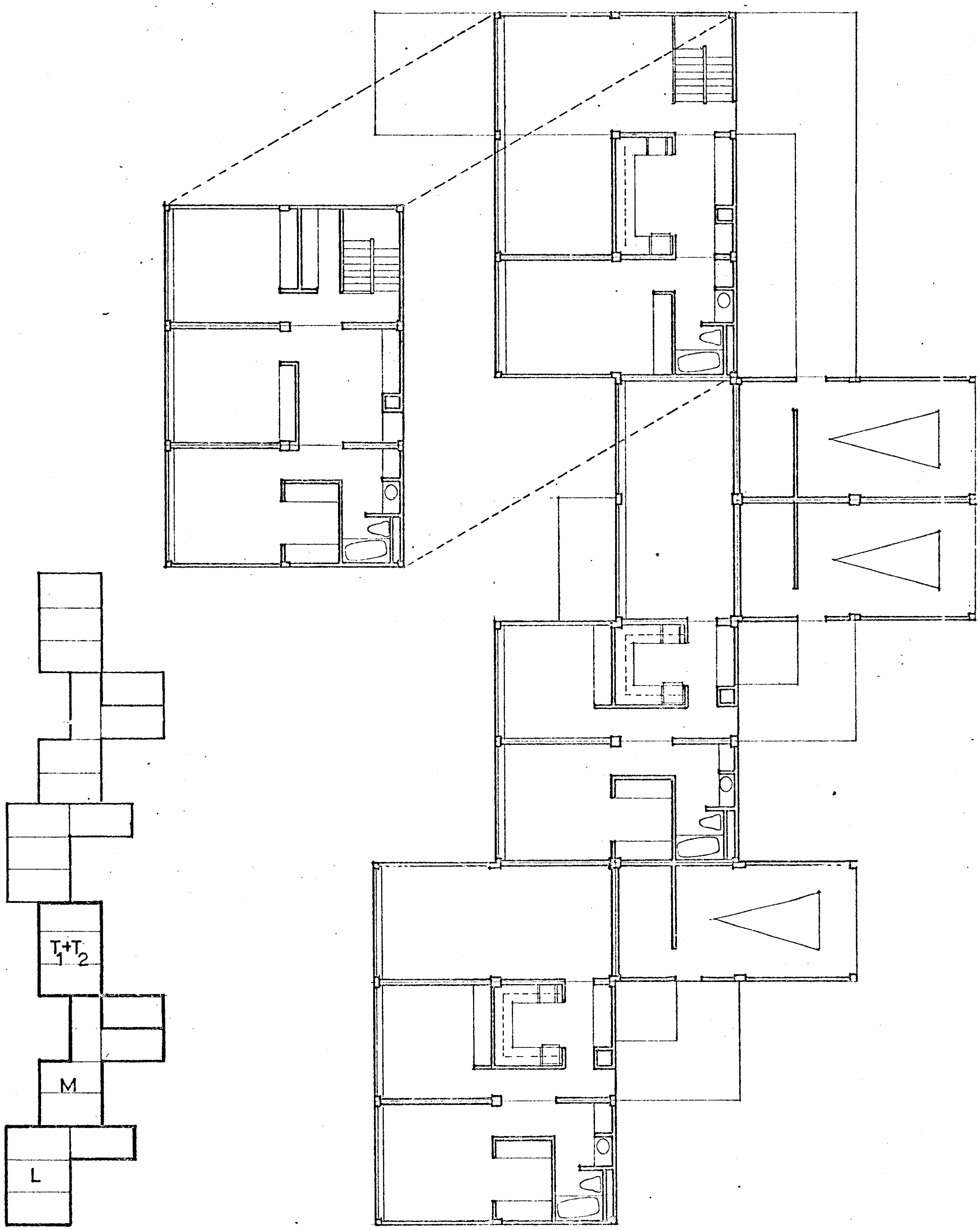

C : G 1 : 7.3

FLOOR PLAN

SCALE $\frac{1}{16}$" = 1' - 0"

MULTI - FAMILY LOW RISE

FIG.80




FLOOR PLAN

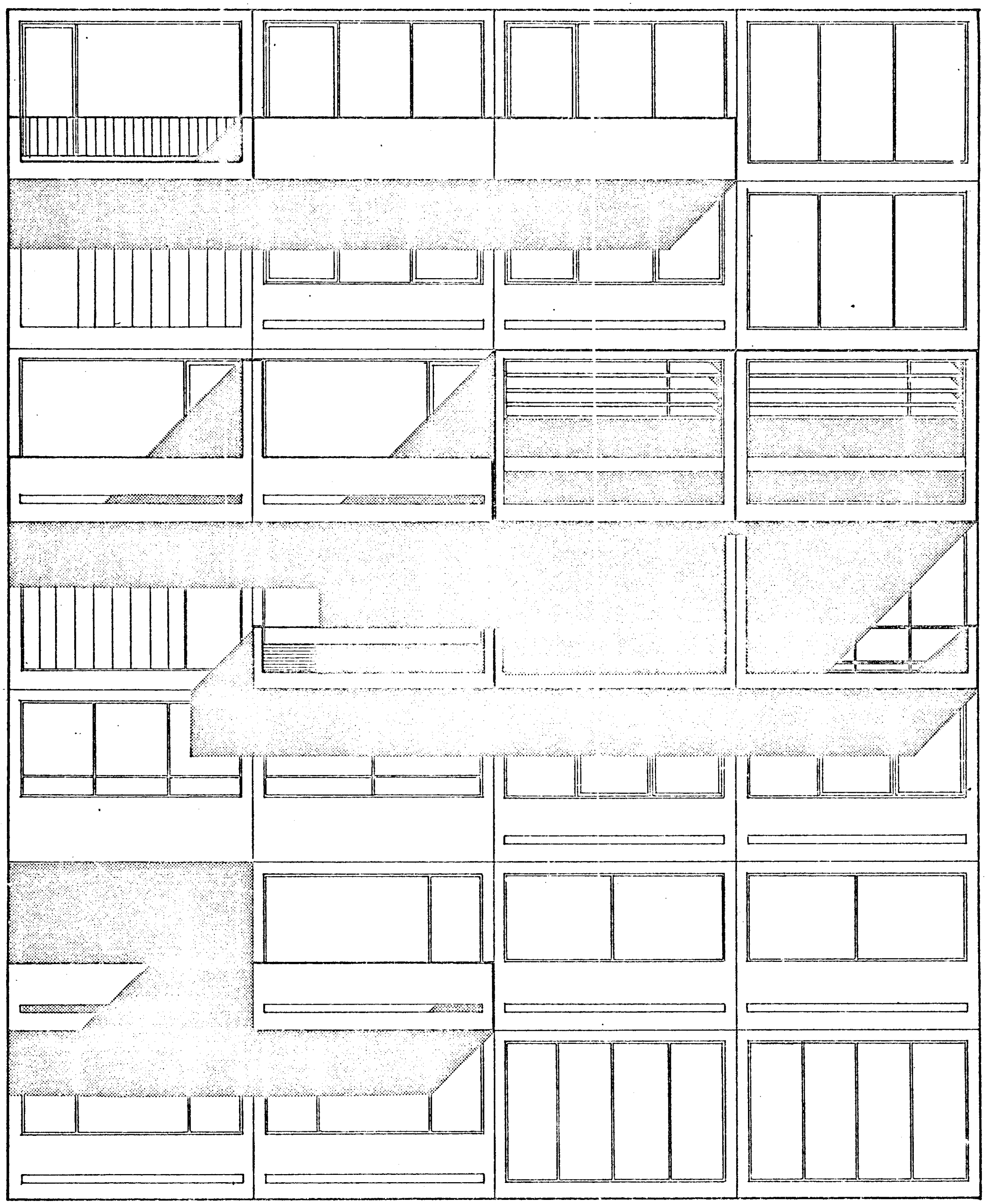
SCALE $\frac{1}{16}''$ = 1' - 0''

SINGLE - FAMILY ATTACHED

ELEVATIONS AND SECTIONS OF HIGH AND LOW RISE BUILDINGS

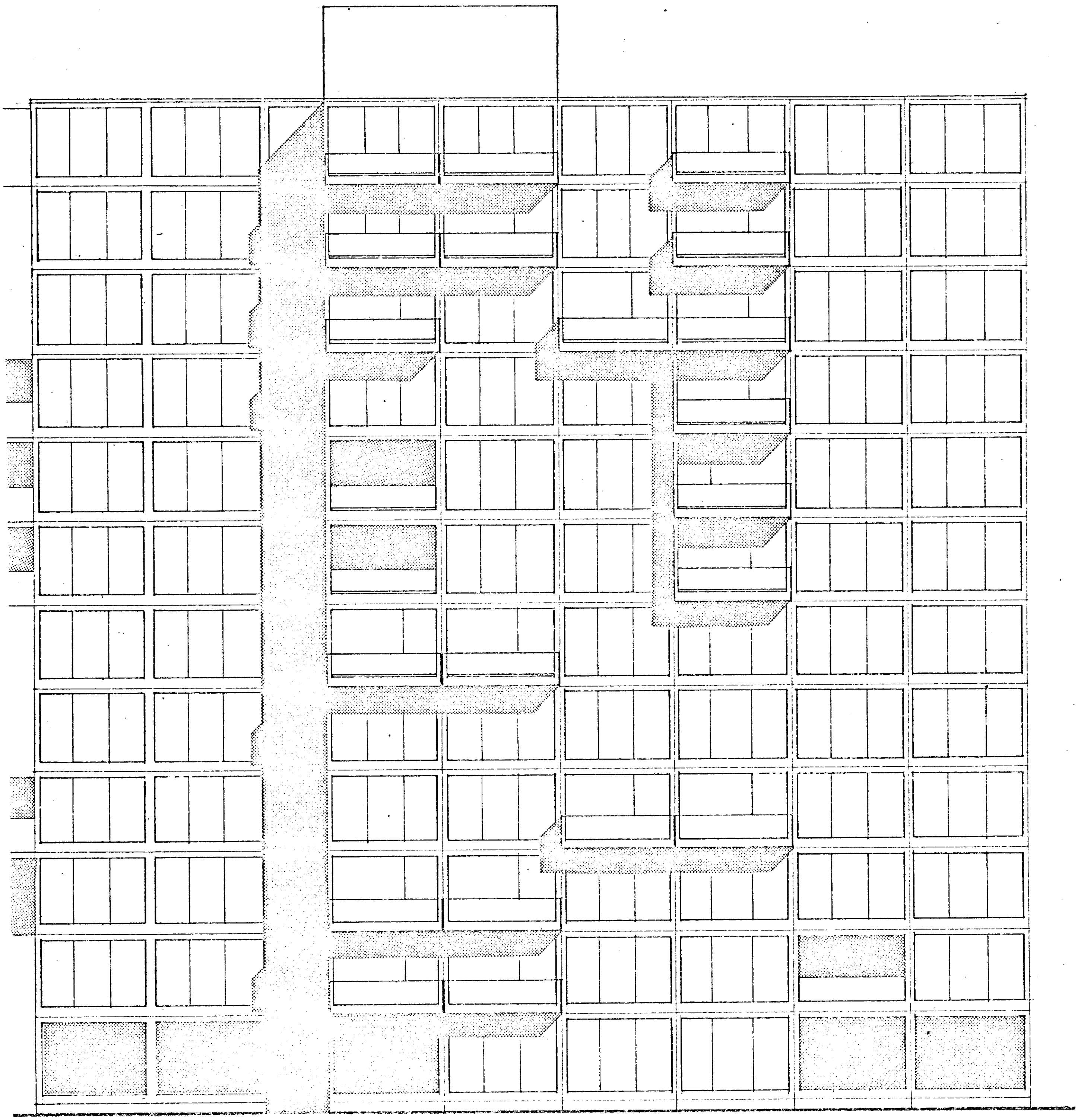
(Figs. 81 - 85)

FIG. 81



SHOWING VARIATION OF FENESTRATION AND BALCONY EXPRESSION

SCALE $\frac{1}{8}'' = 1' - 0''$ COMPOSITE ELEVATION

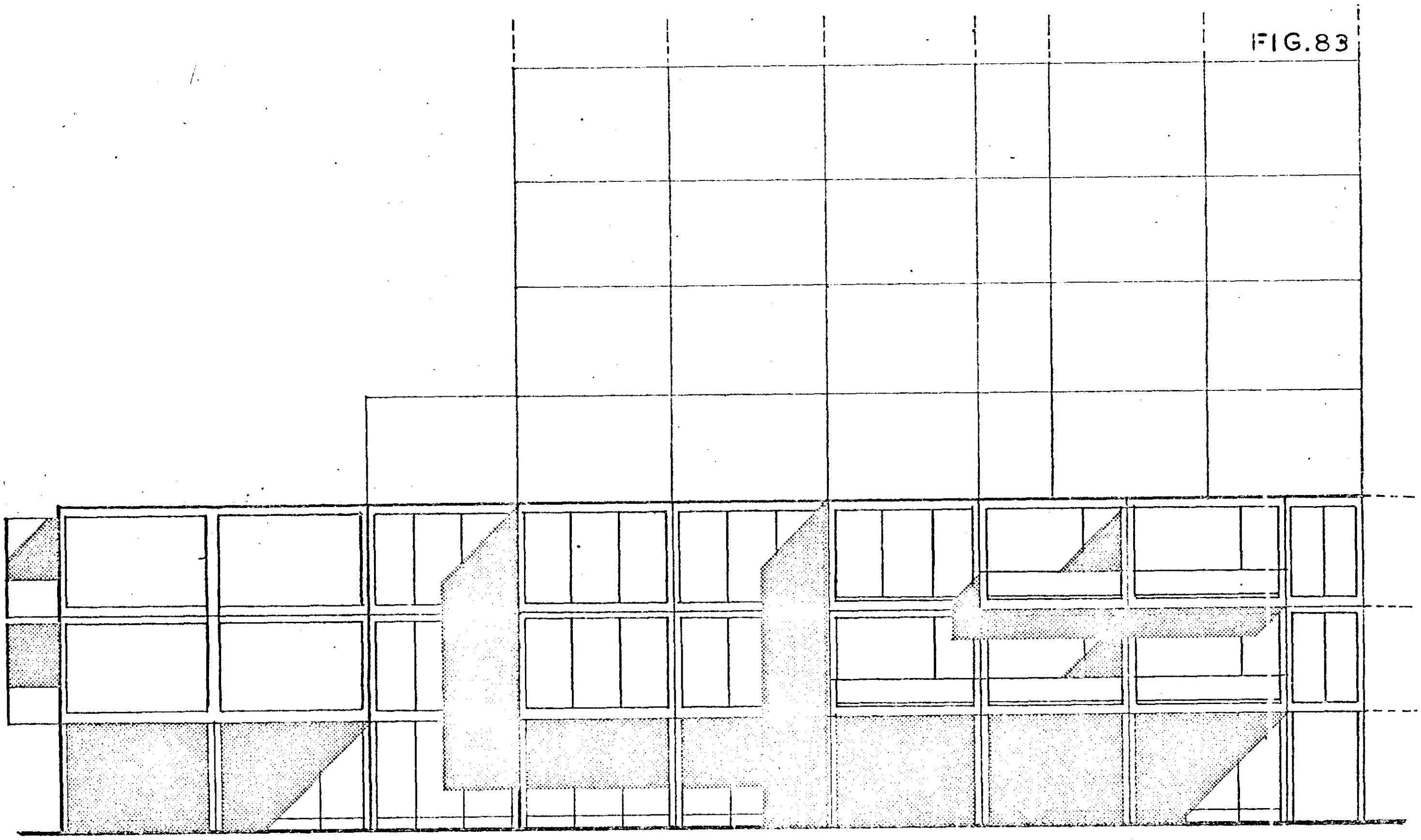


ELEVATION

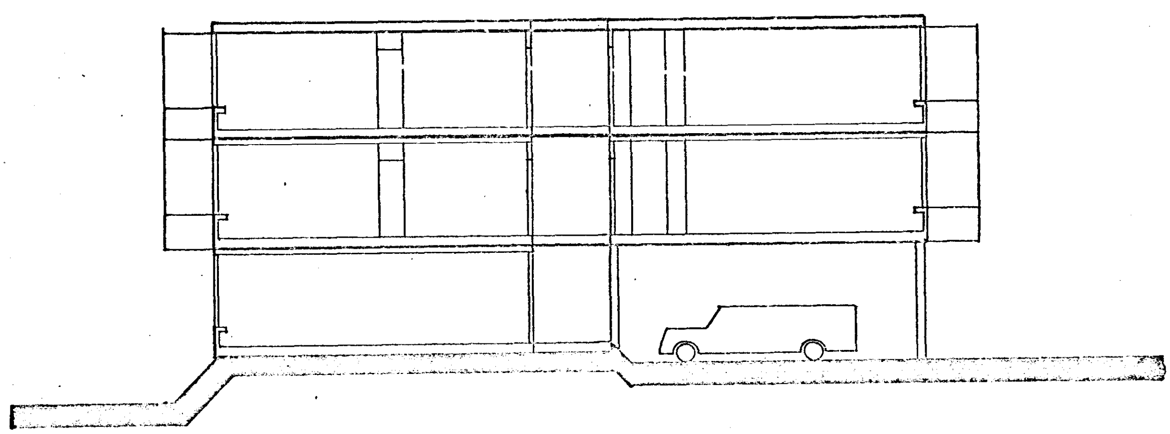
SCALE $\frac{1}{16}'' = 1'-0''$

MULTI - FAMILY HIGH RISE

FIG. 83



ELEVATION

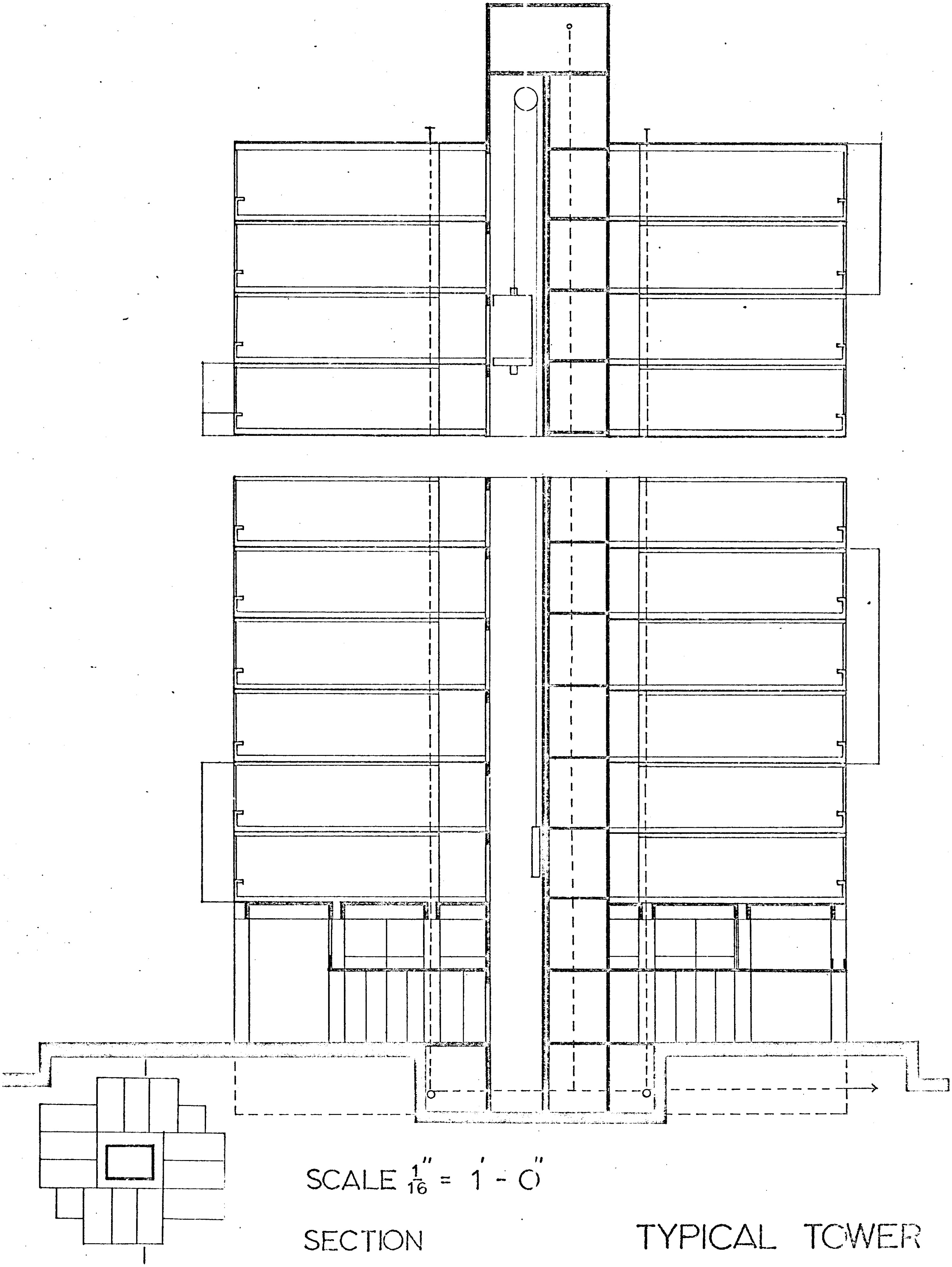


SECTION

SCALE $\frac{1}{16}$" = 1' - 0"

MULTI - FAMILY LOW RISE

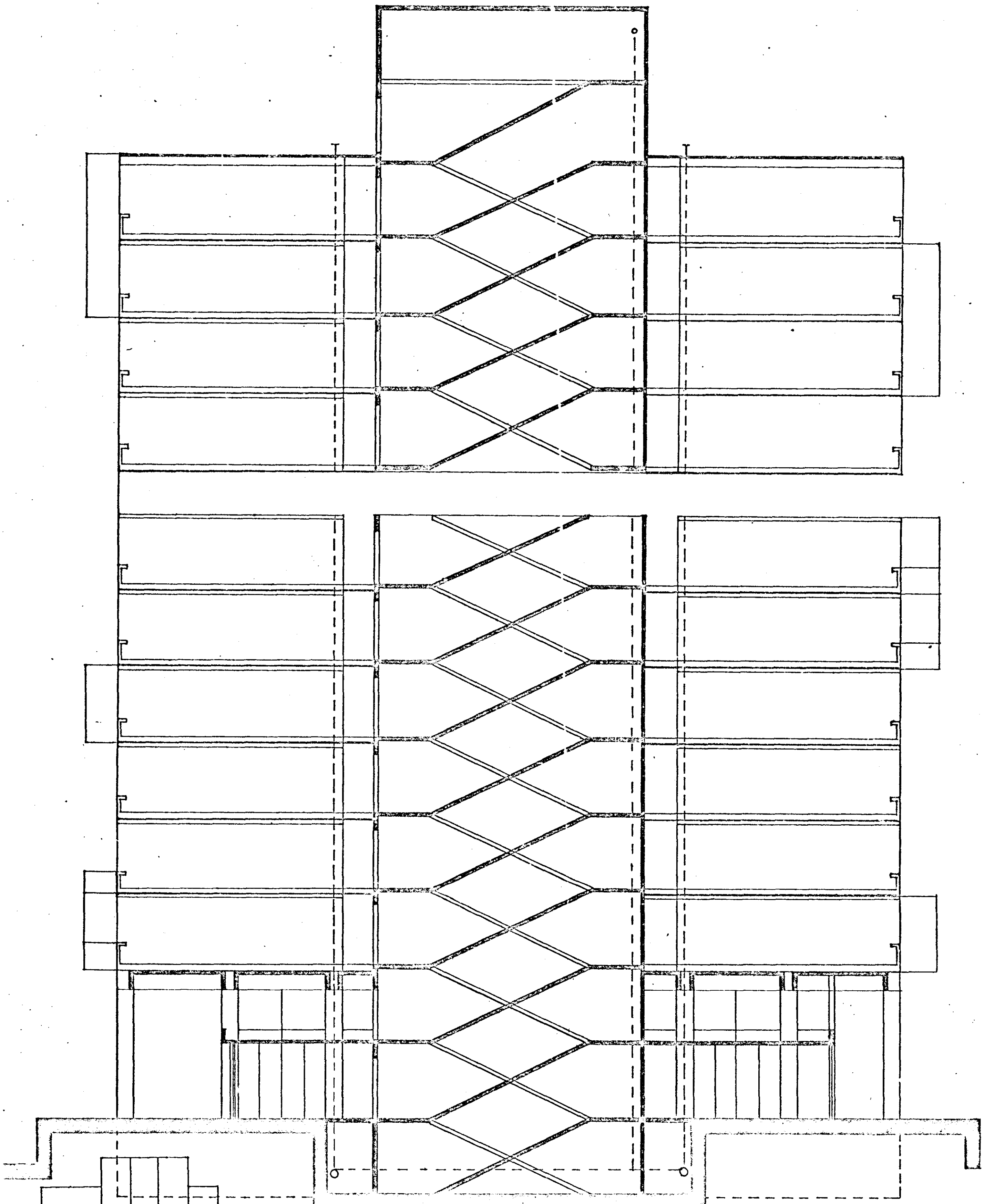
FIG. 84

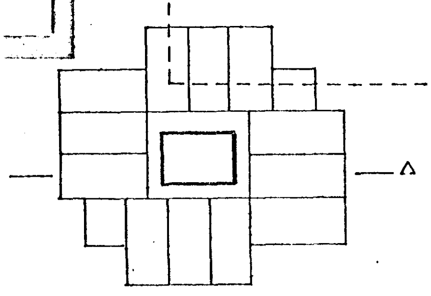


SCALE $\frac{1}{16}'' = 1' - 0''$

SECTION

TYPICAL TOWER





SCALE $\frac{1}{16}'' = 1' - 0''$

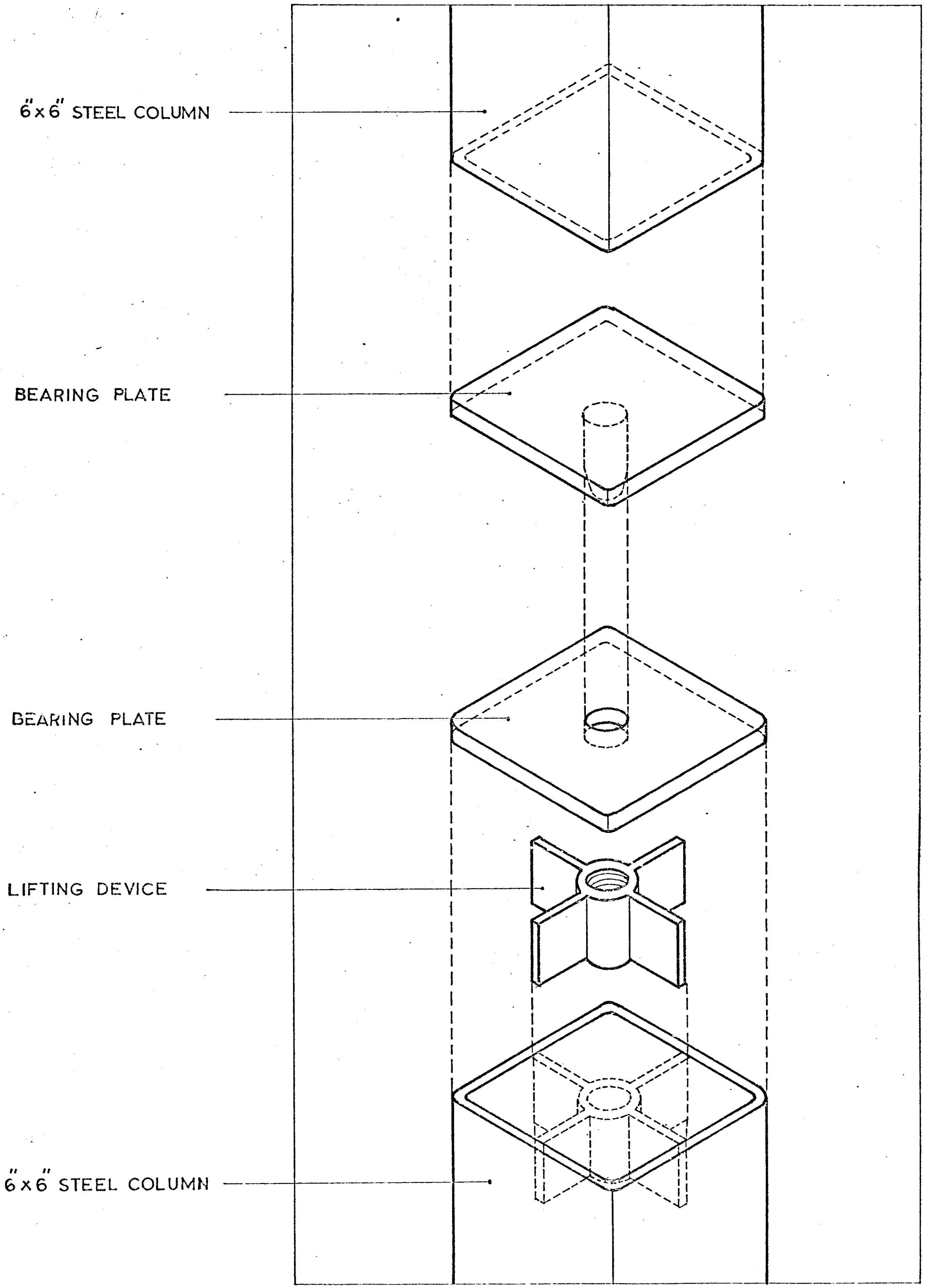
SECTION

TYPICAL TOWER

DETAILS OF CONSTRUCTION (Figs. 86 - 98)

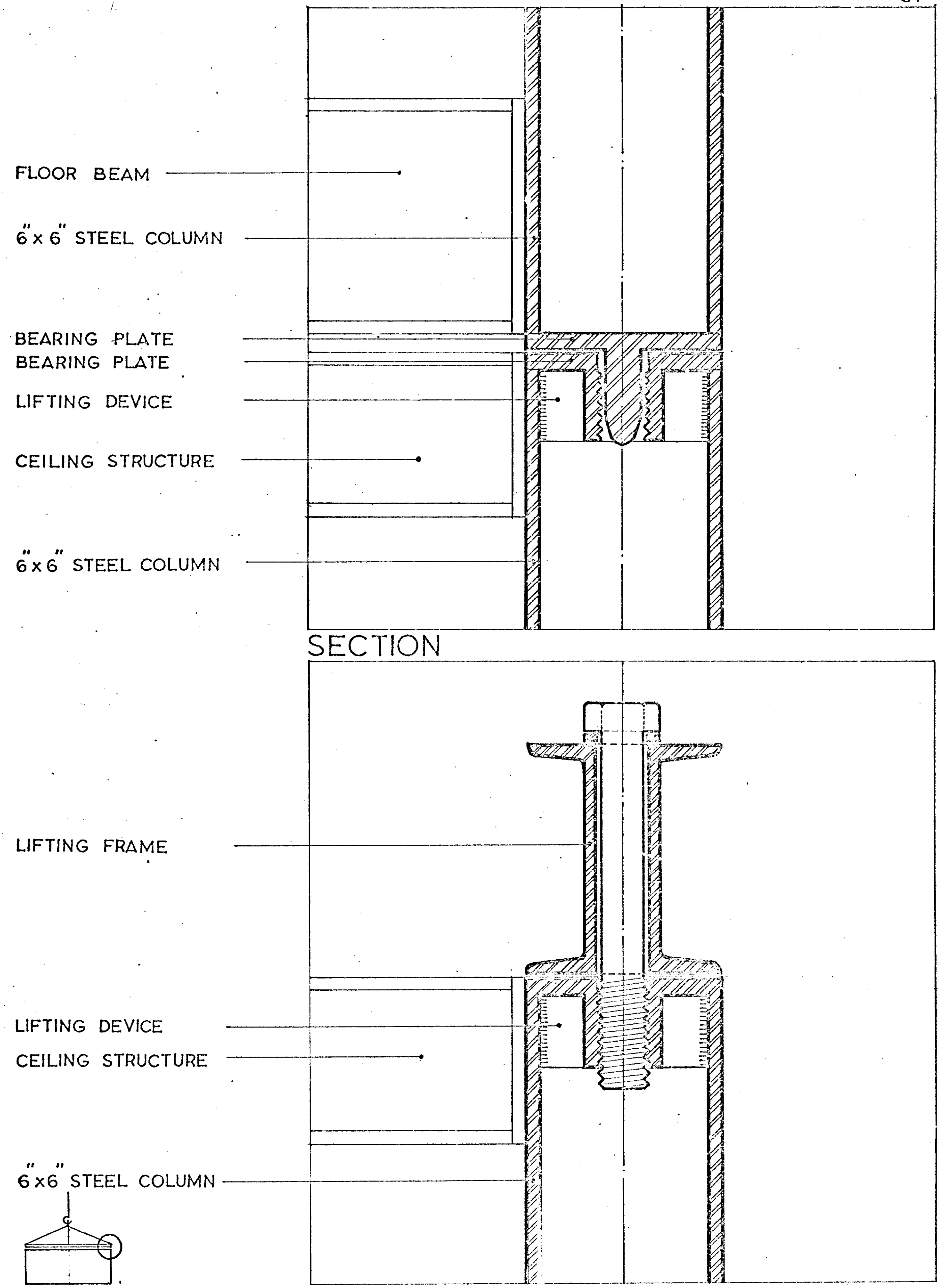
SEQUENCE OF ERECTION (Figs. 99 - 103)

FIG. 86




SCALE $\frac{1}{4}$ FULL SIZE COLUMN No. VERTICAL CONNECTION

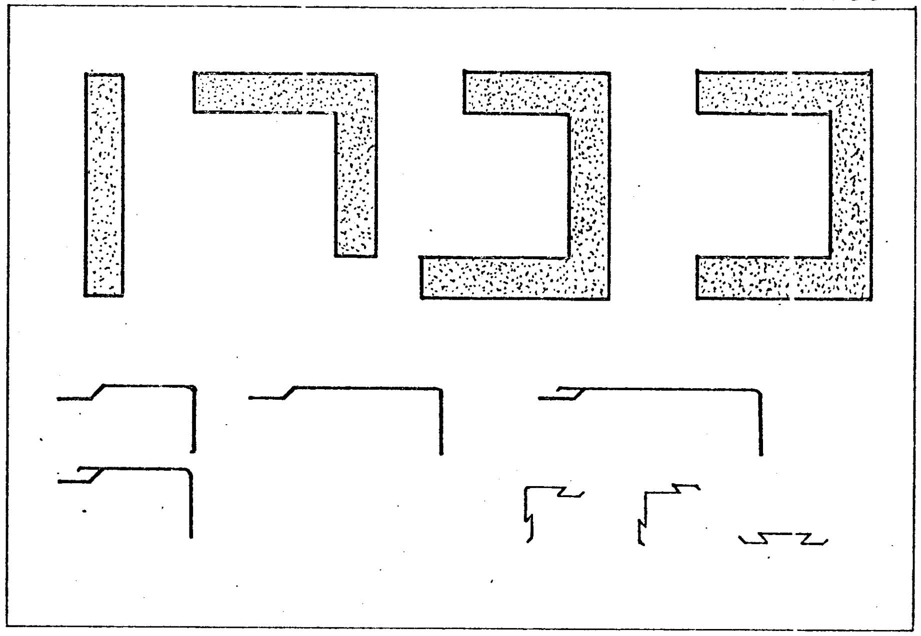
FIG. 87



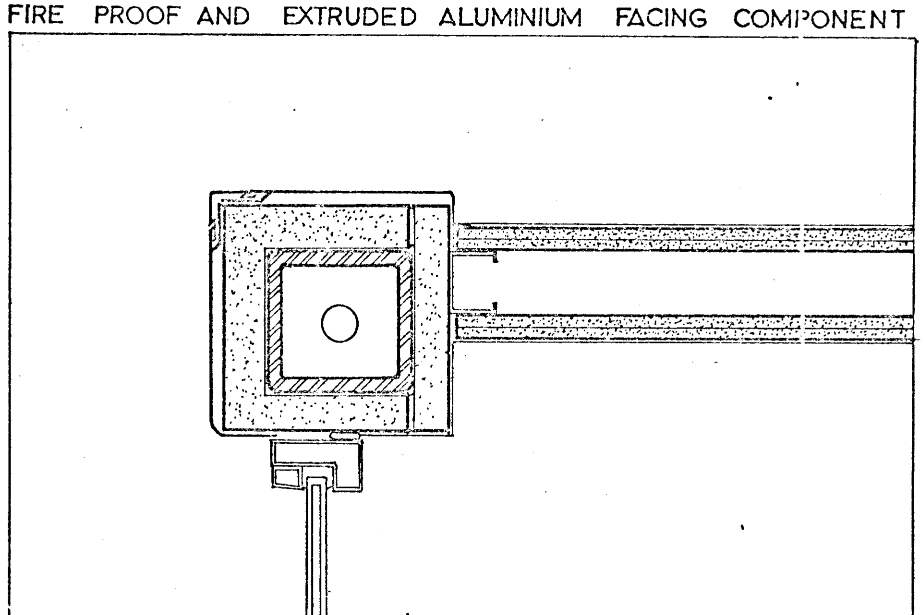

SCALE $\frac{1}{4}$ FULL SIZE

COLUMN VERTICAL CONNECTION

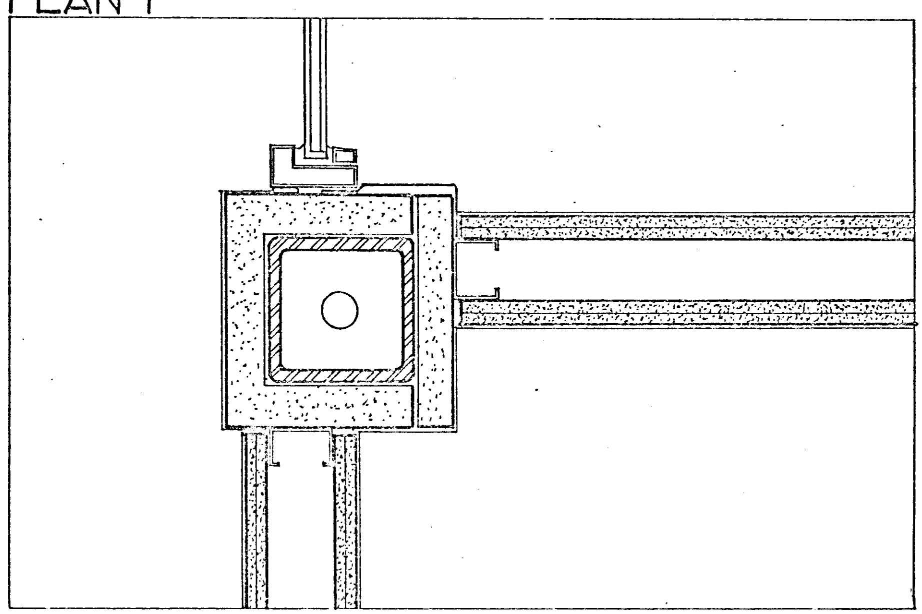
FIG. 88

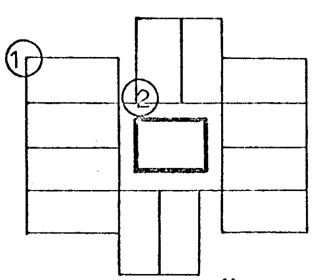


FIRE PROOF AND EXTRUDED ALUMINIUM FACING COMPONENT



PLAN 1



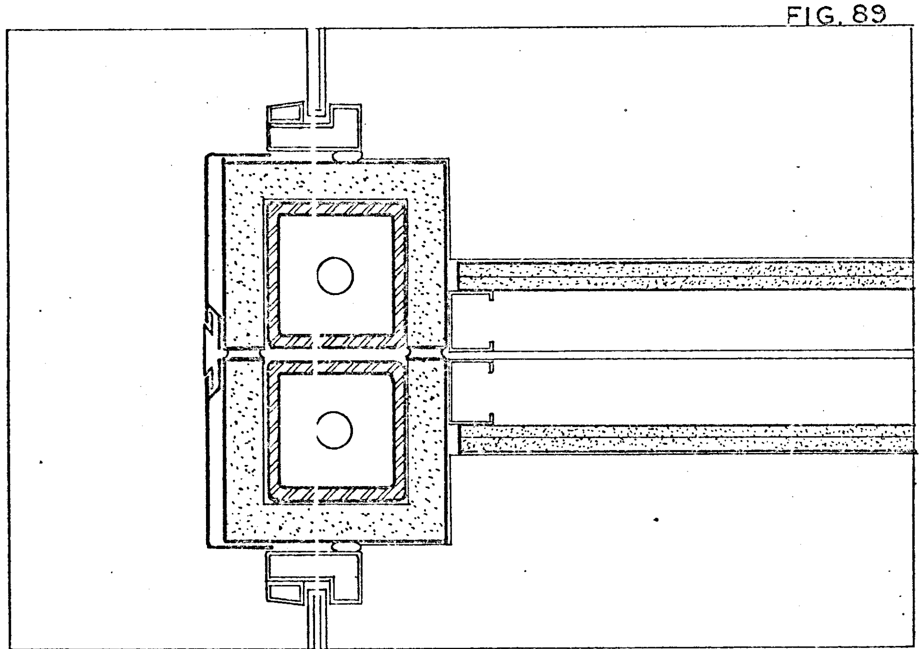



SCALE 1½" = 1'-0"

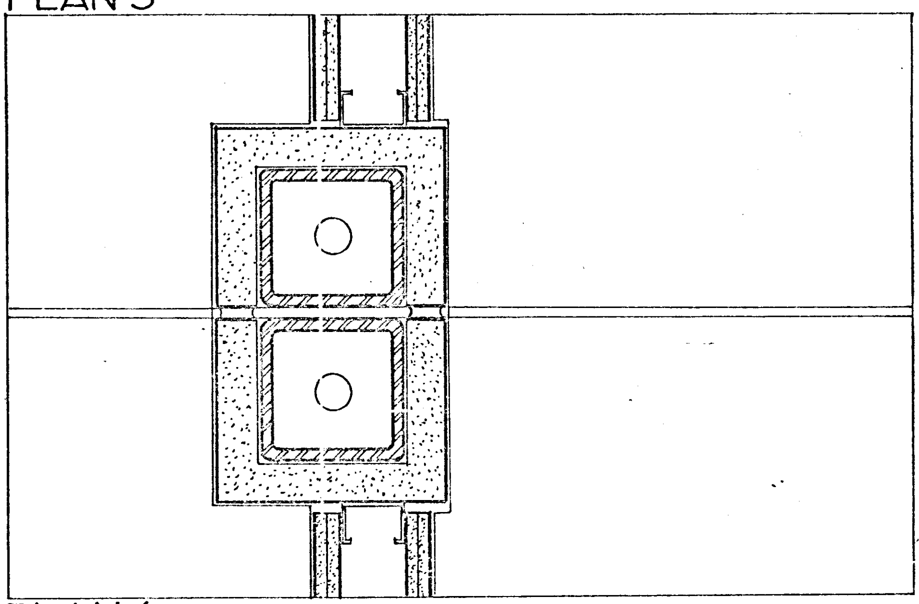
PLAN 2

CONNECTION OF COLUMN

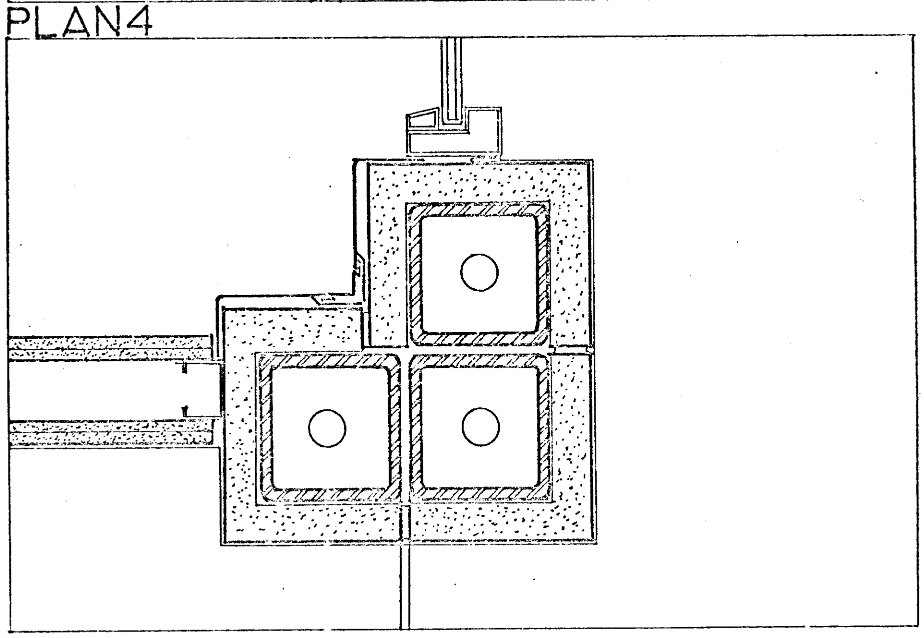
FIG. 89

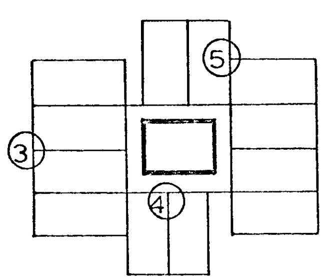


PLAN 3



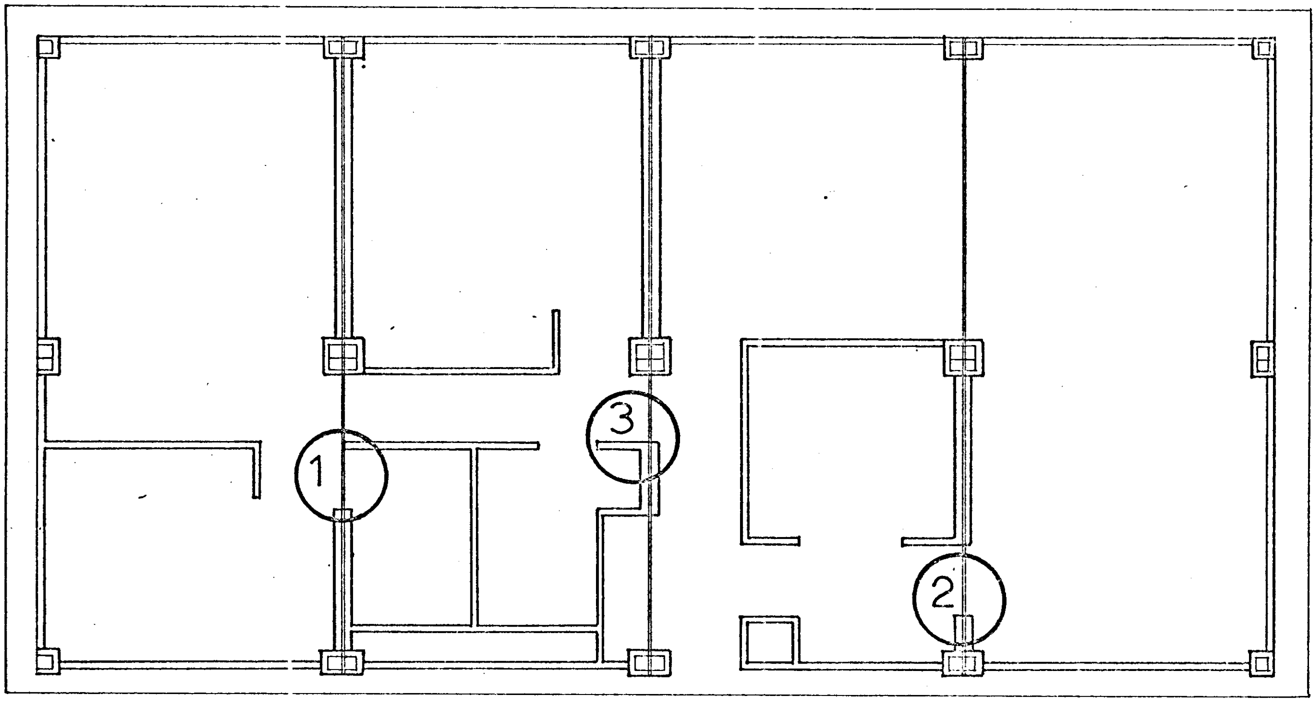
PLAN4

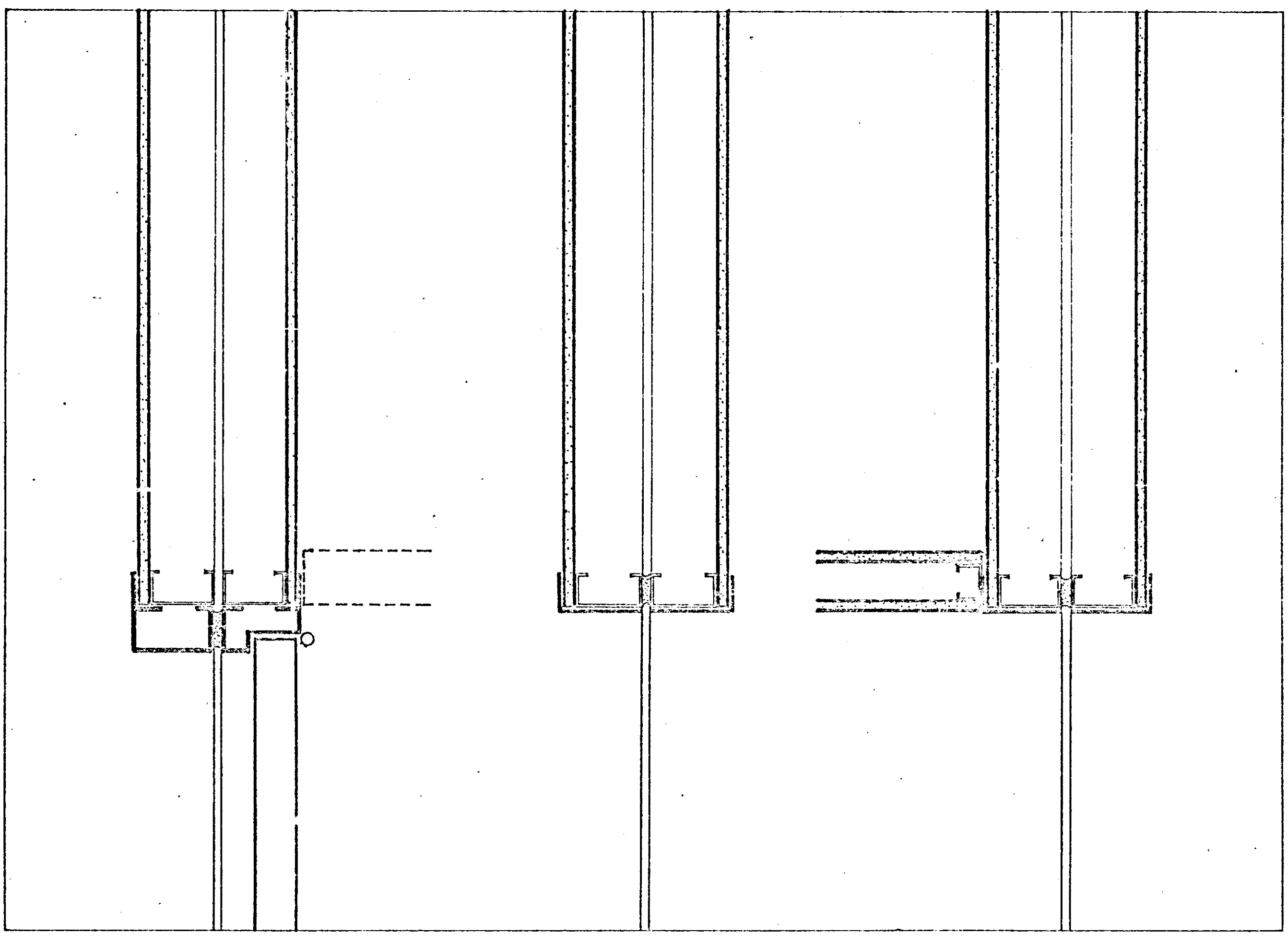





SCALE $1\frac{1}{2}'' = 1' - 0''$ PLAN 5 CONNECTION & COLUMN

FIG. 90

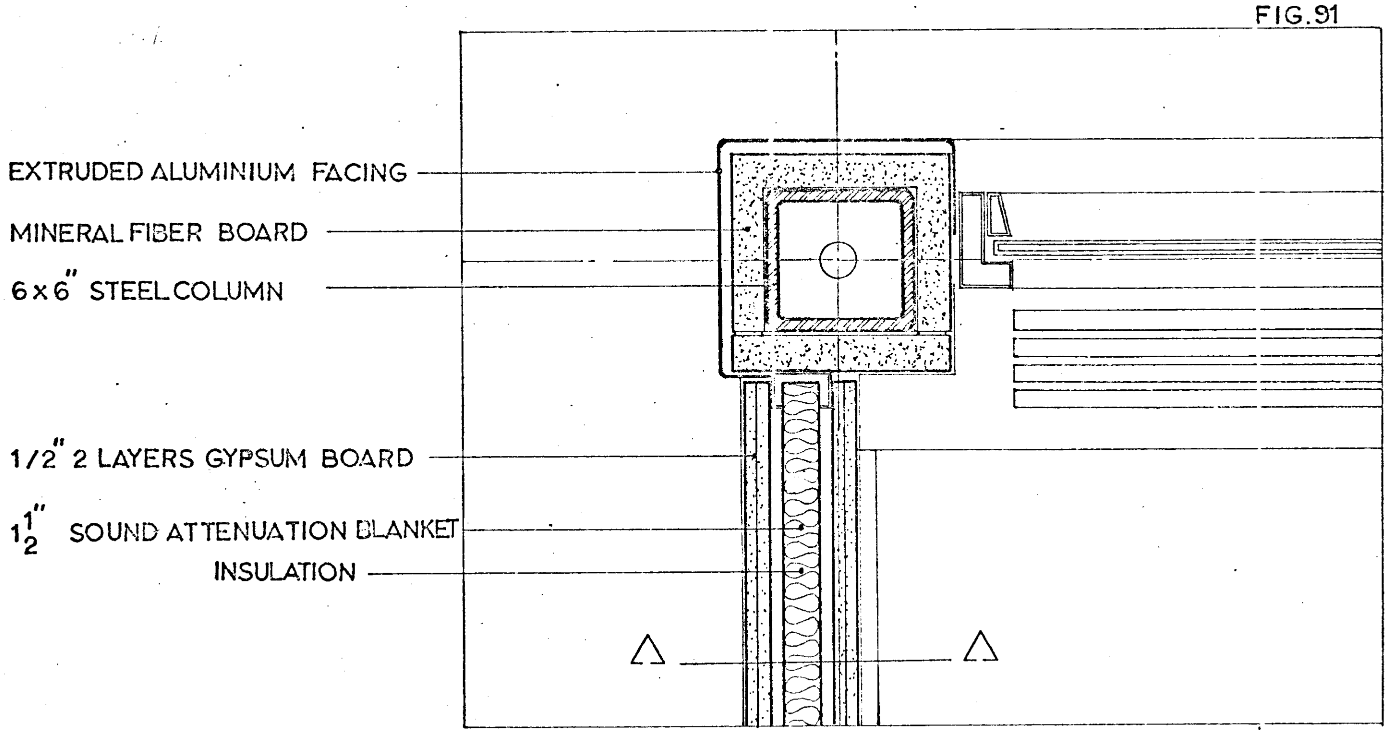


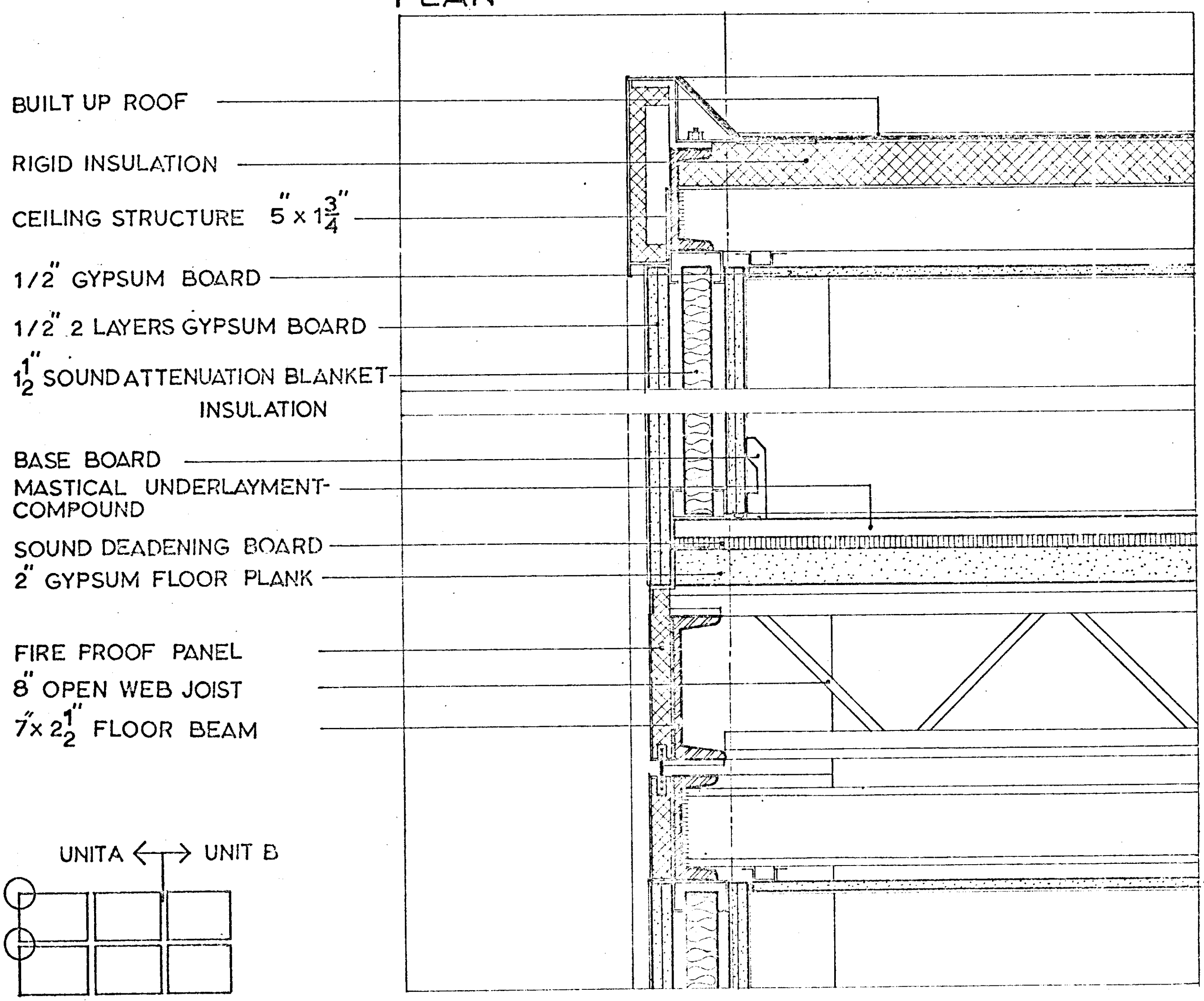
PLAN

SCALE $1\frac{1}{2}'' = 1'-0''$ WALL CONNECTION

FIG. 91



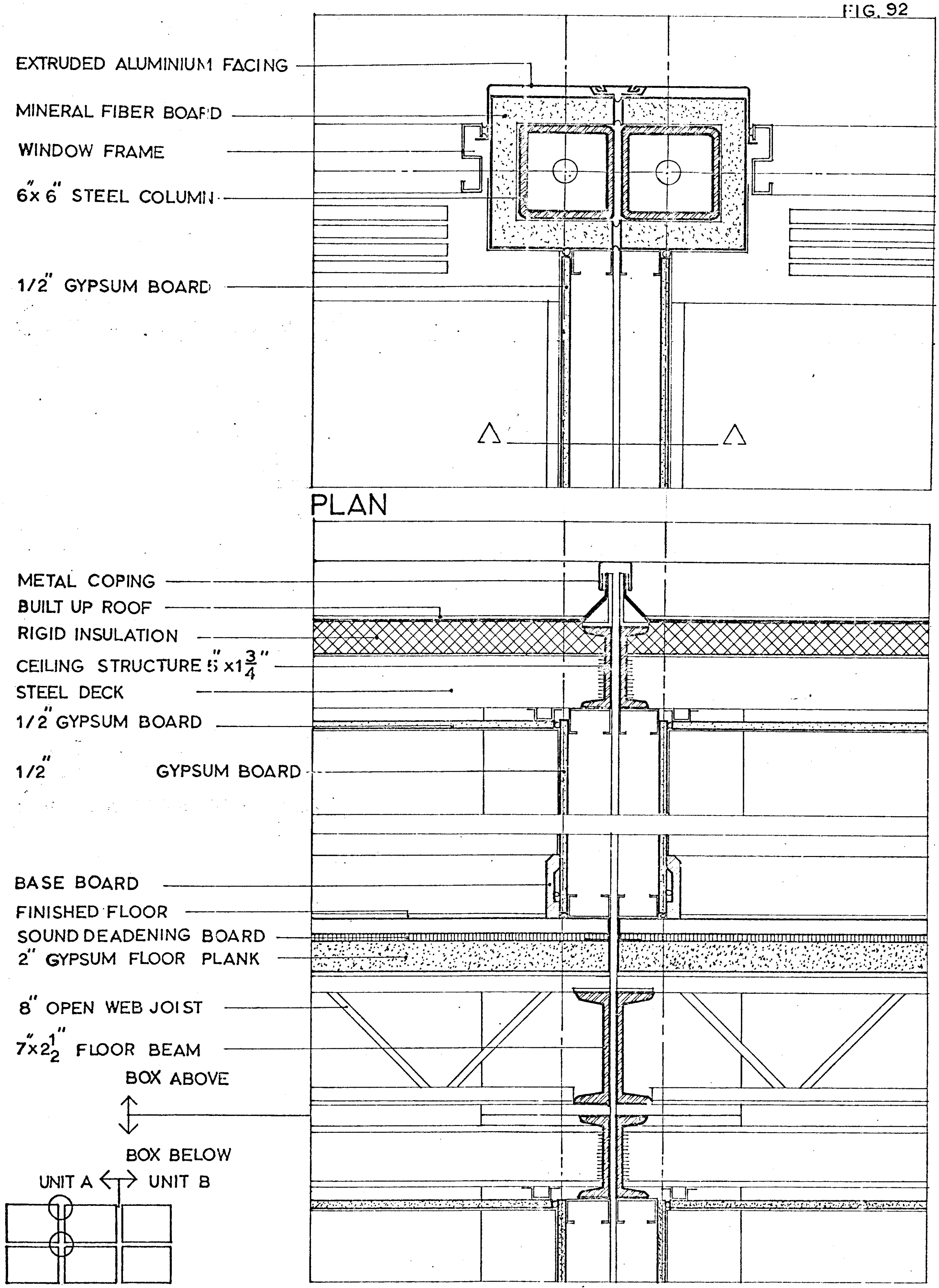

PLAN




SCALE 1½" = 1'-0" SECTION

EXTERNAL WALL

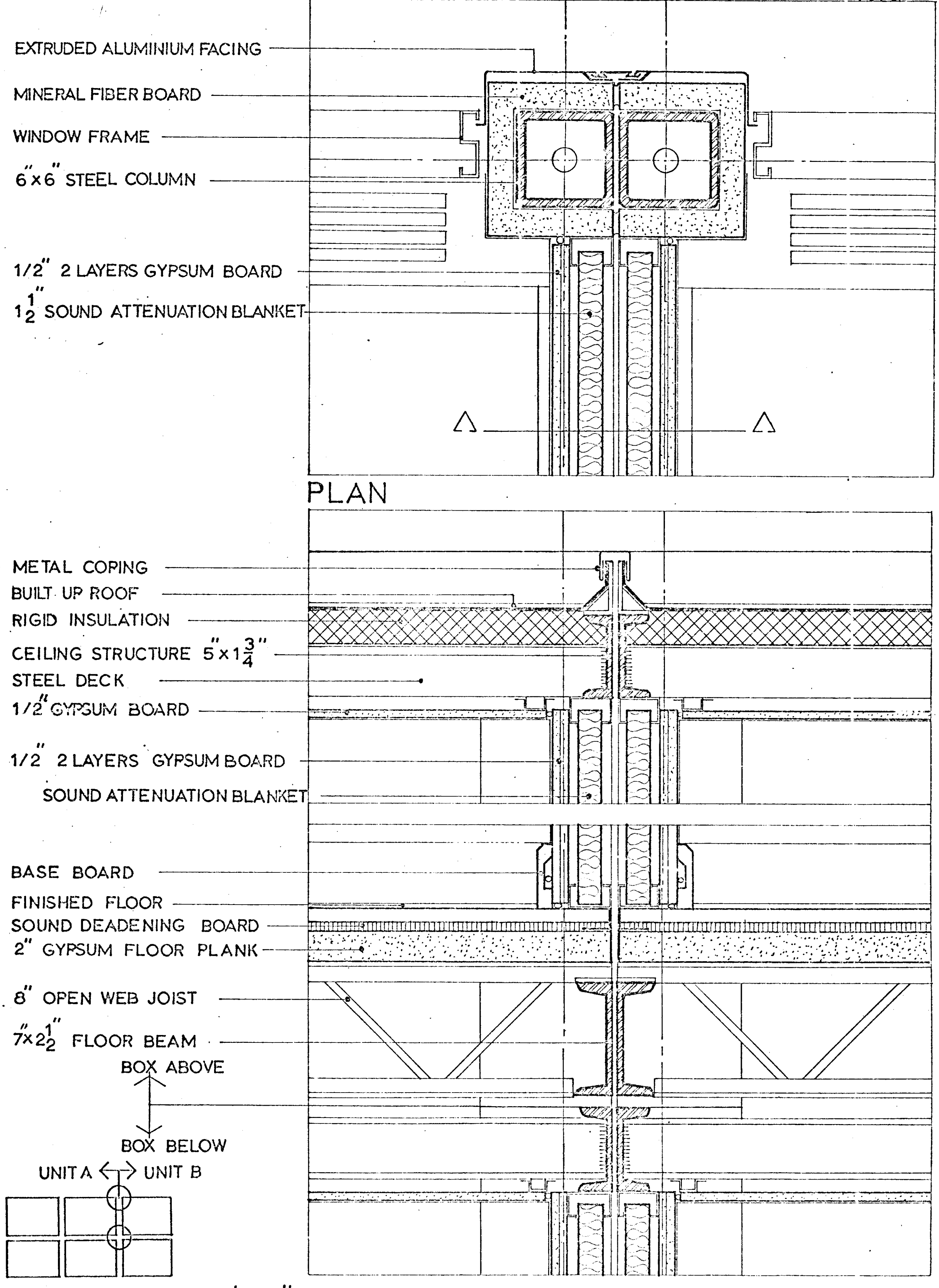
FIG. 92




SCALE $1\frac{1}{2}$" = 1'-0" SECTION

WALL

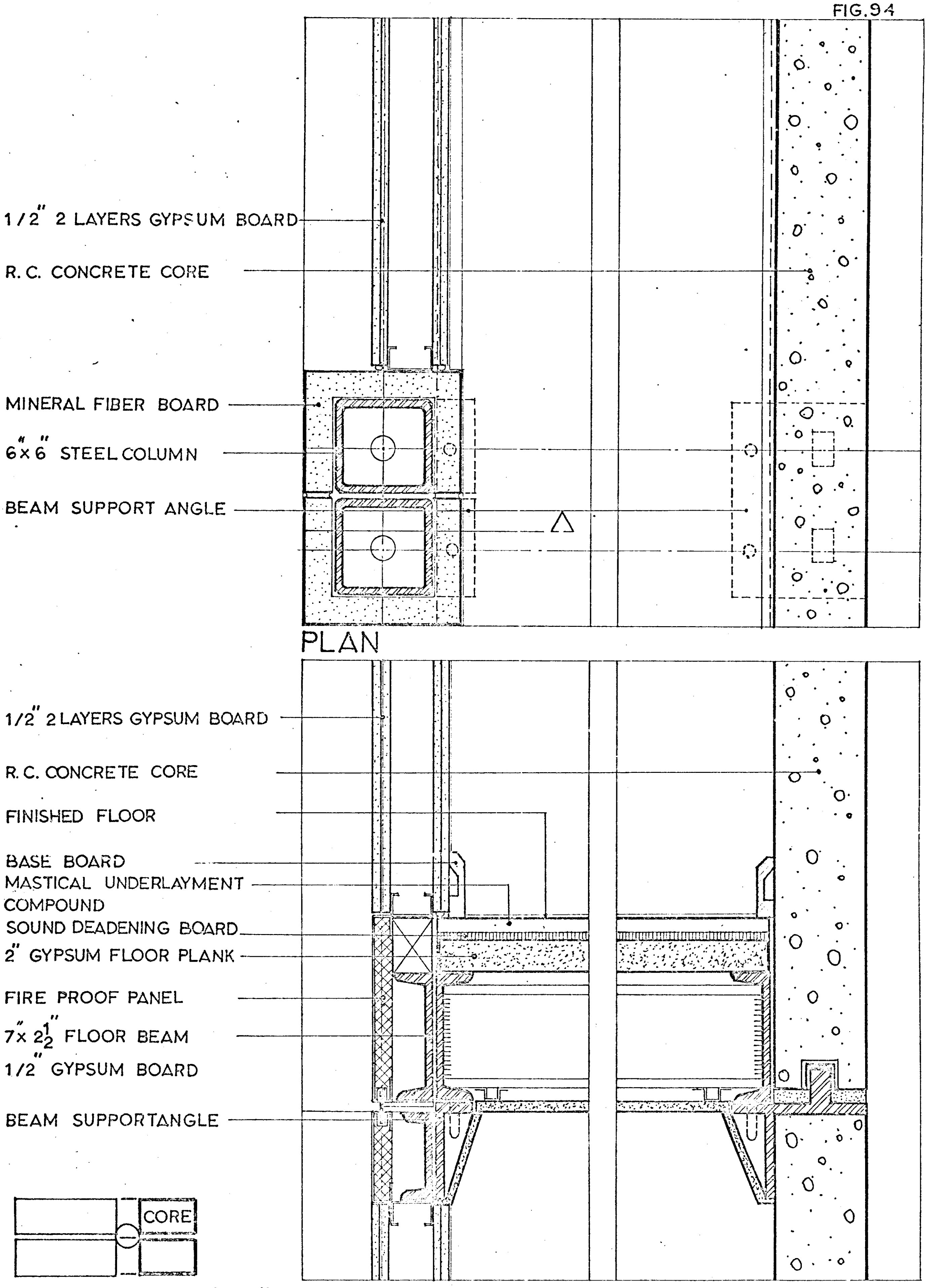
FIG. 93




SCALE 1½" = 1'-0" SECTION

PARTY WALL

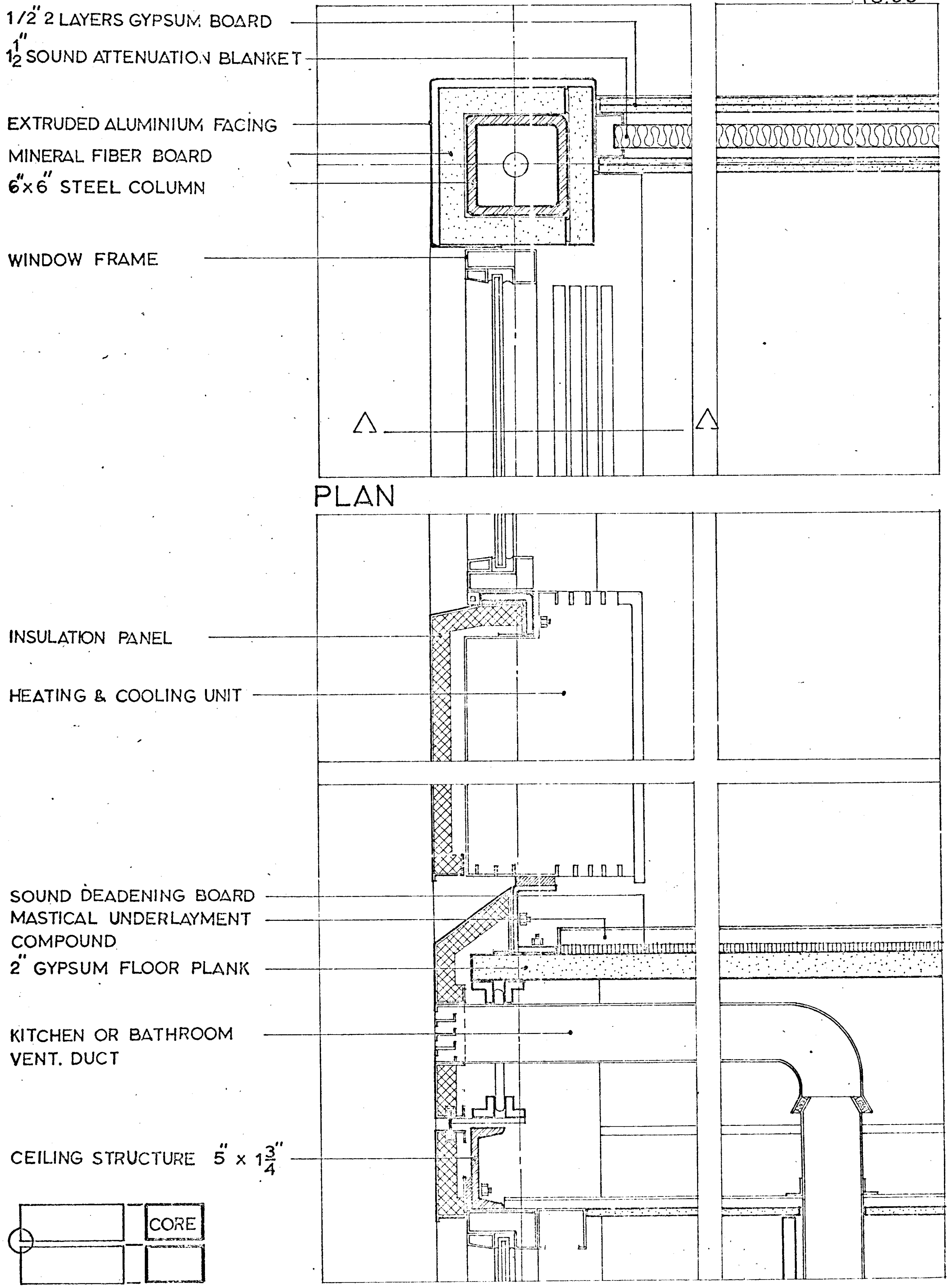
FIG.94




SCALE 1½" = 1'-0" SECTION

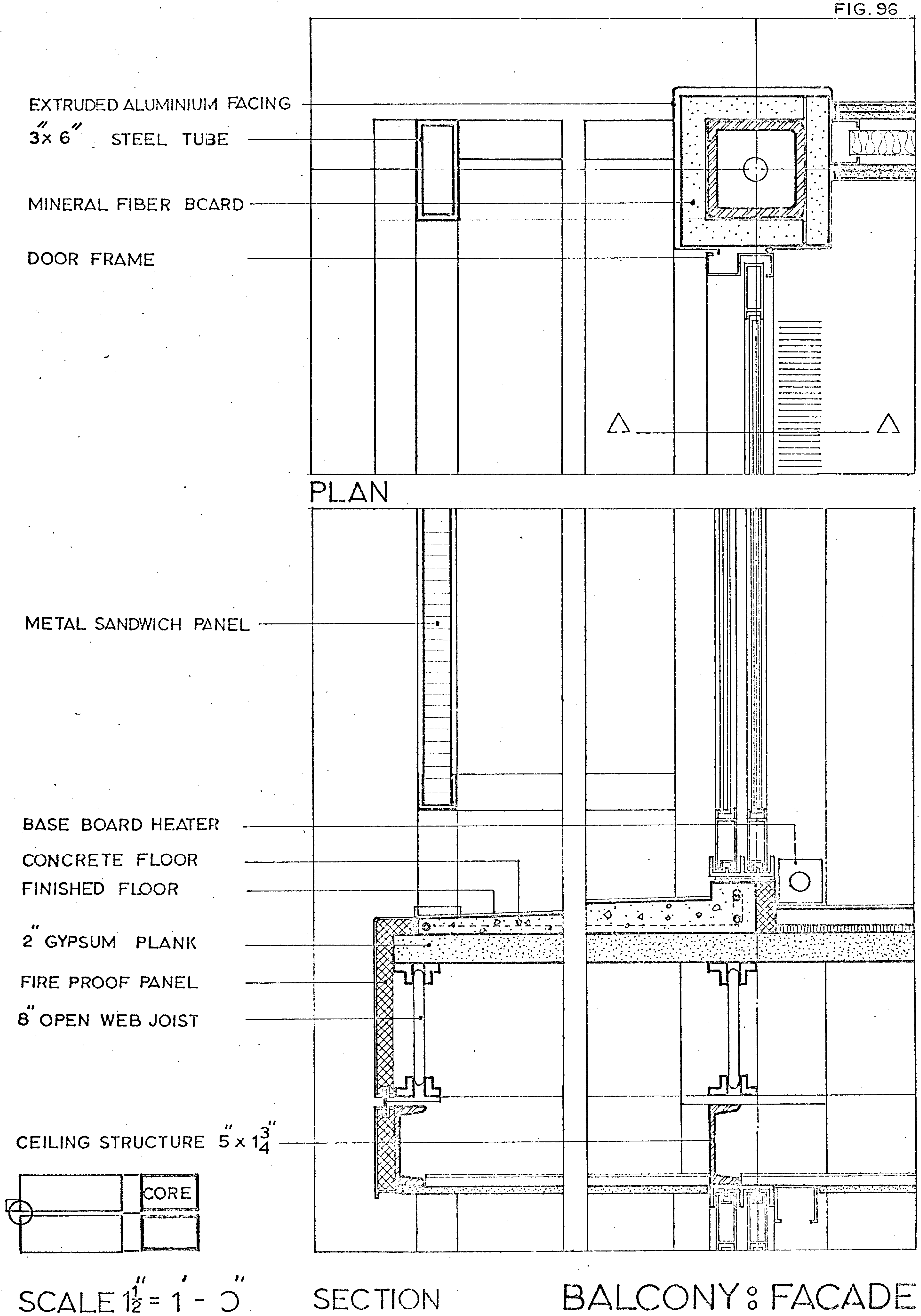
CORRIDOR

FIG. 95

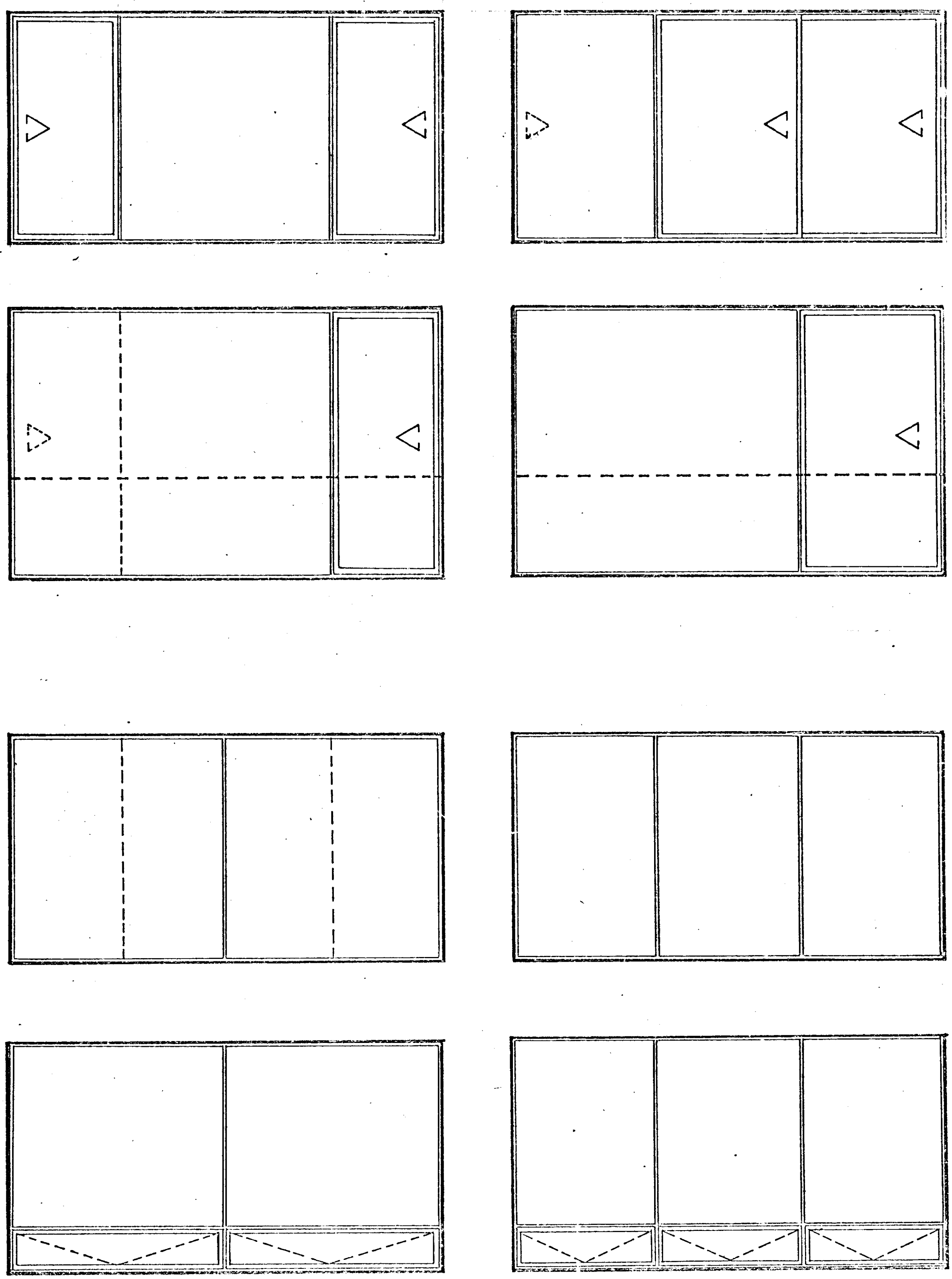



SCALE 1½" = 1'-0" SECTION

FACADE

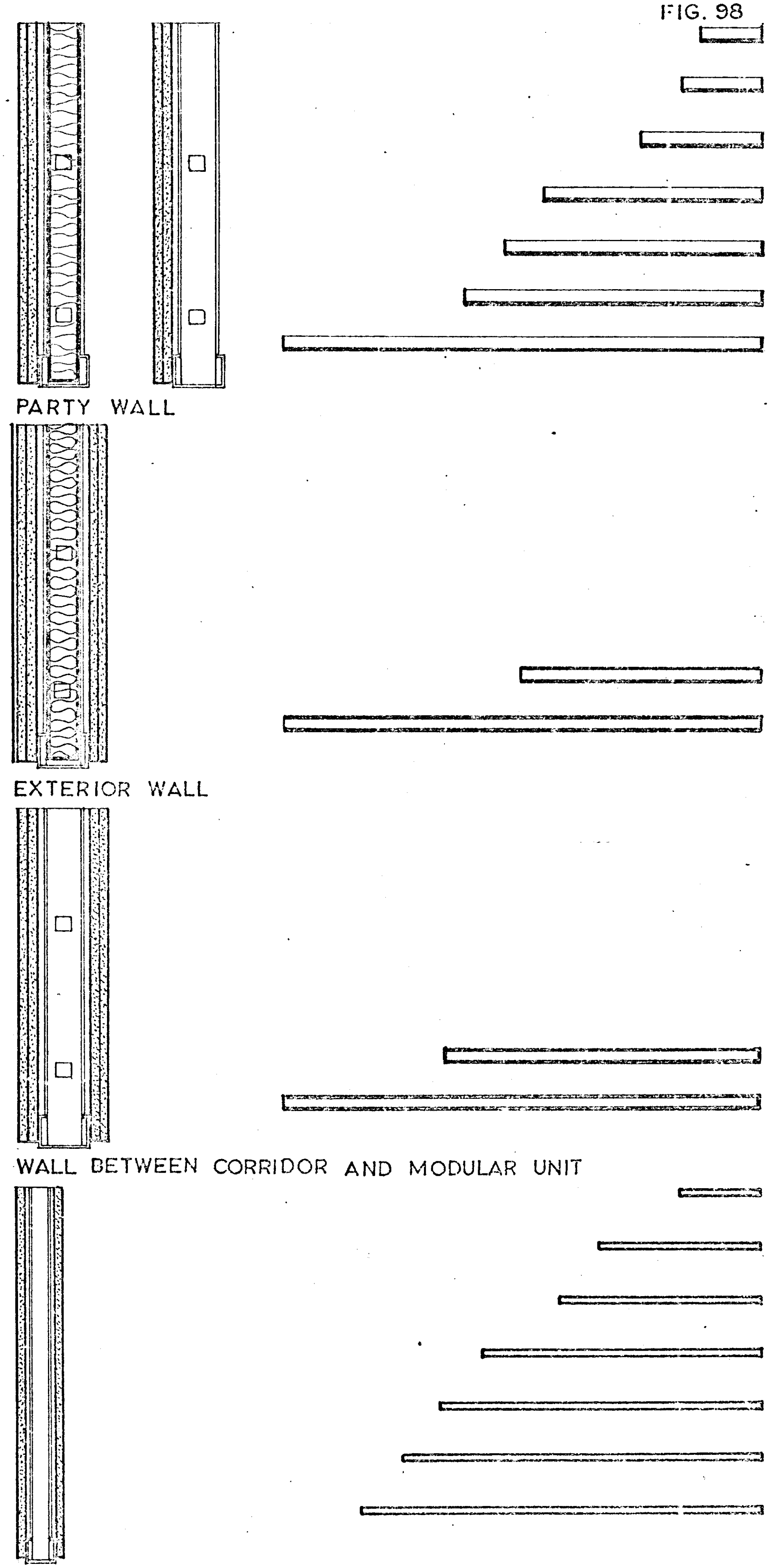



SCALE 1½" = 1' - 0" SECTION BALCONY : FACADE



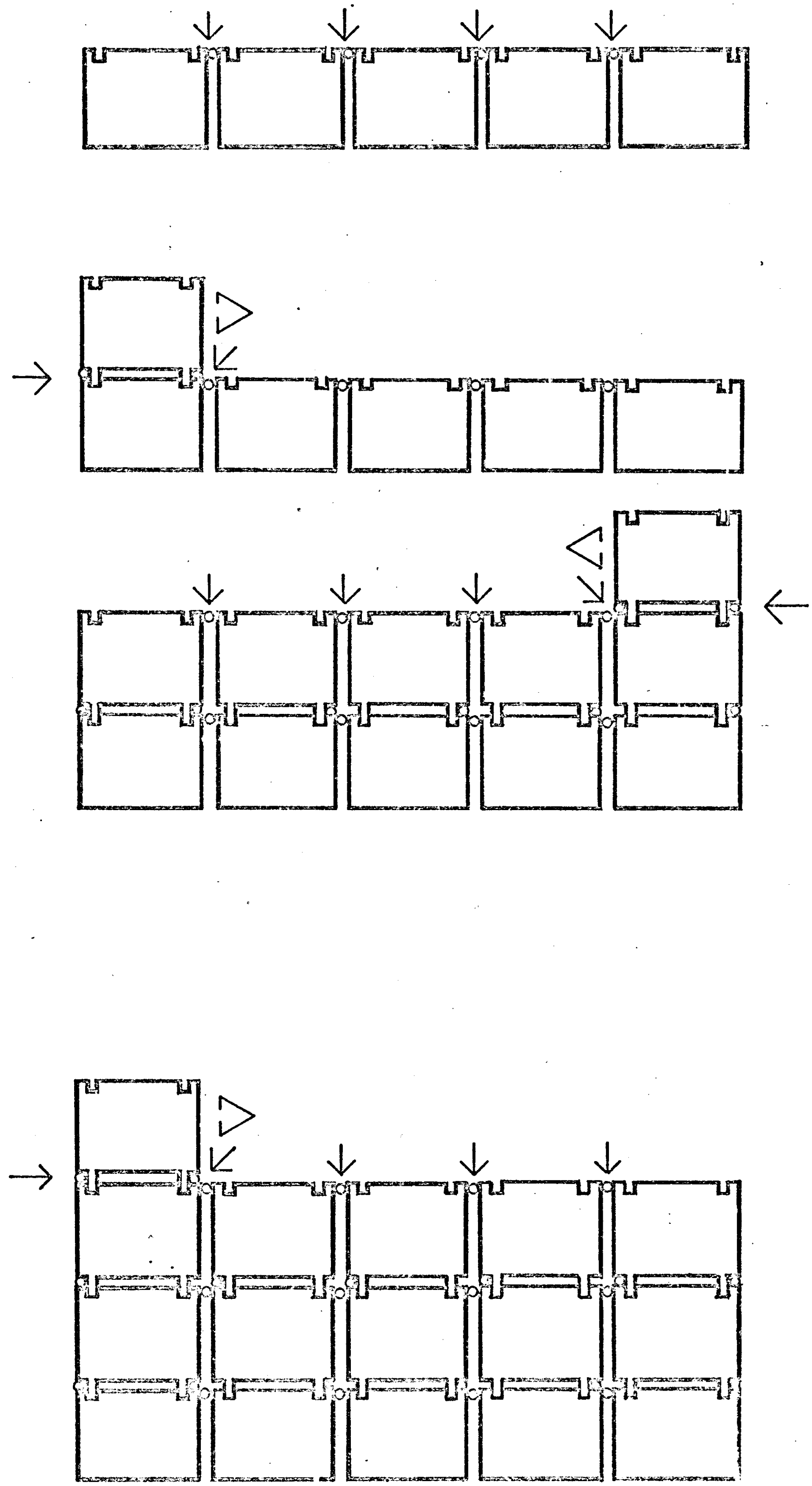
SCALE $\frac{1}{4}''$ = 1'-0"    ELEVATION    WINDOW

FIG. 98

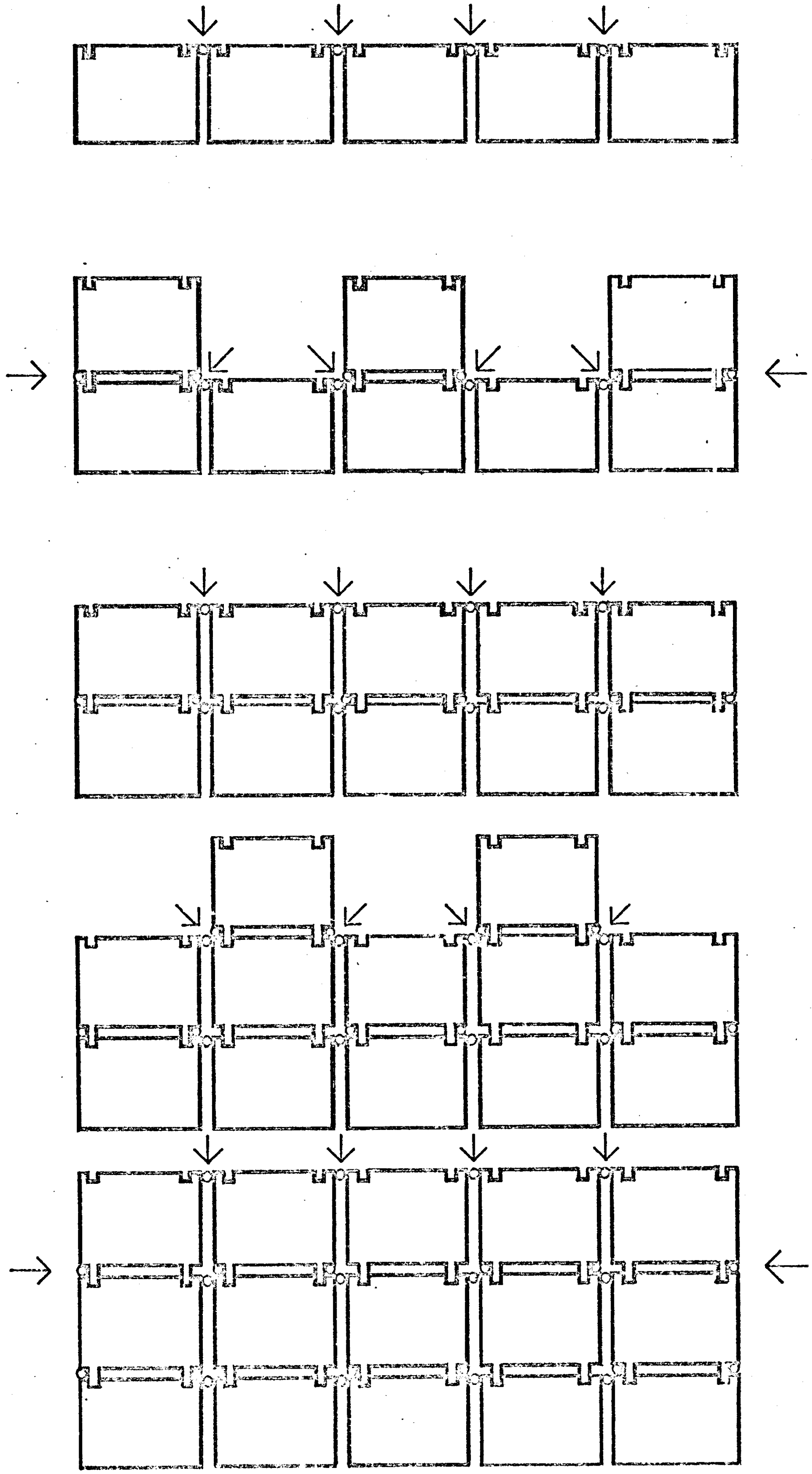



SCALE $1\frac{1}{2}'' = 1'-0''$ SECTION PLAN SCALE $\frac{1}{4}'' = 1'-0''$ WALL

FIG. 99
DWELLING MODULAR UNIT

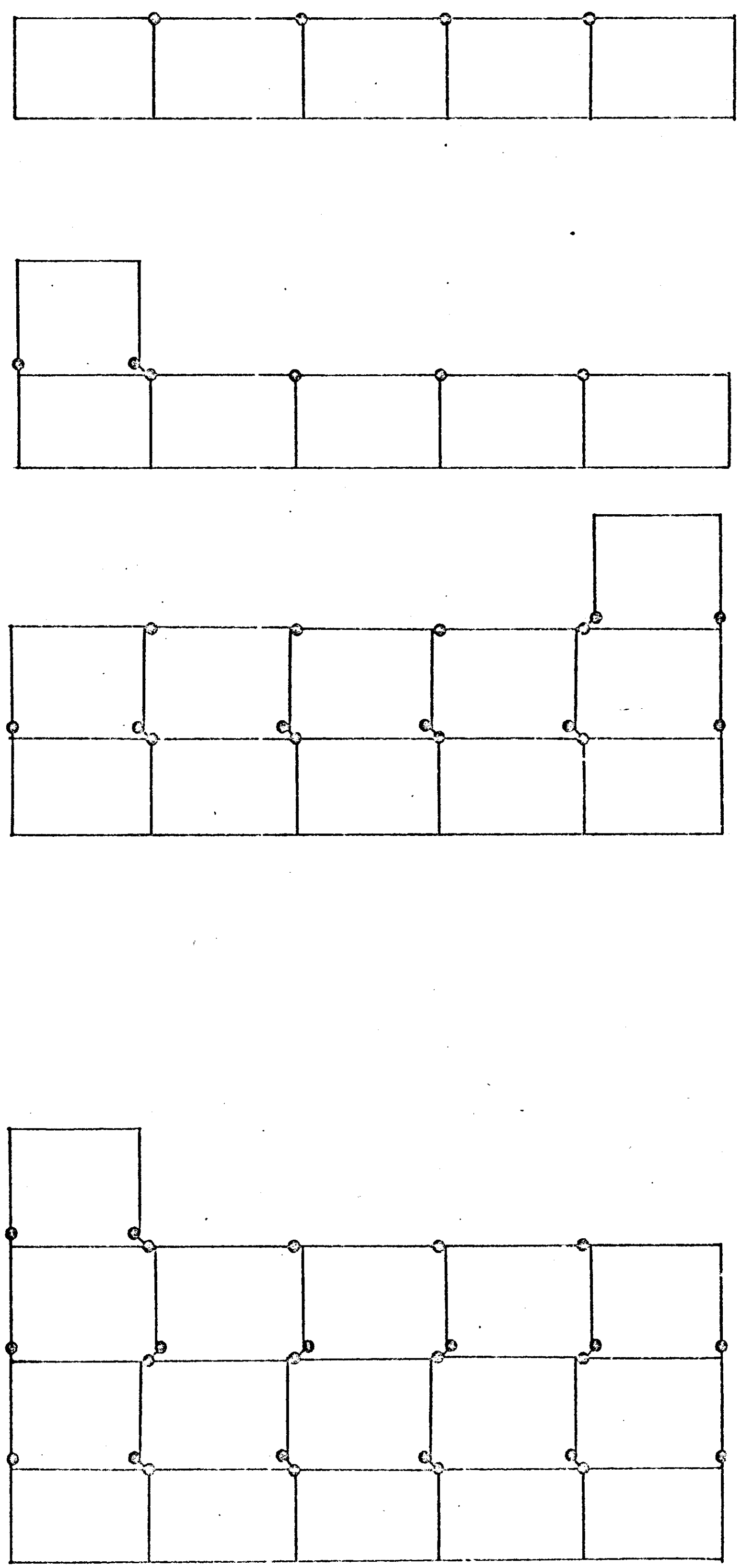


NO SCALE DIAGRAM: CONSTRUCTION SEQUENCE A



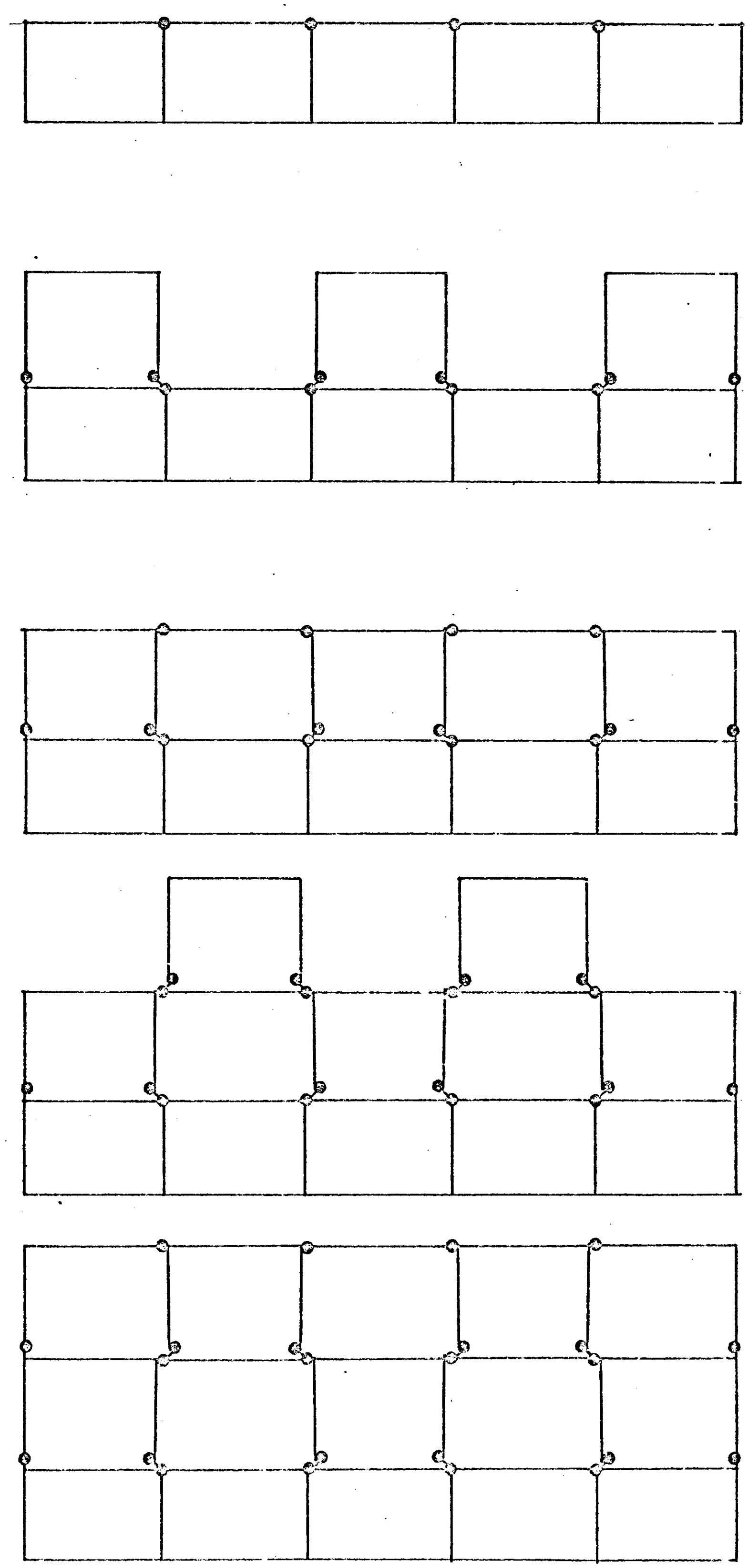
NO SCALE DIAGRAM: CONSTRUCTION SEQUENCE: B

FIG. 101



NO SCALE

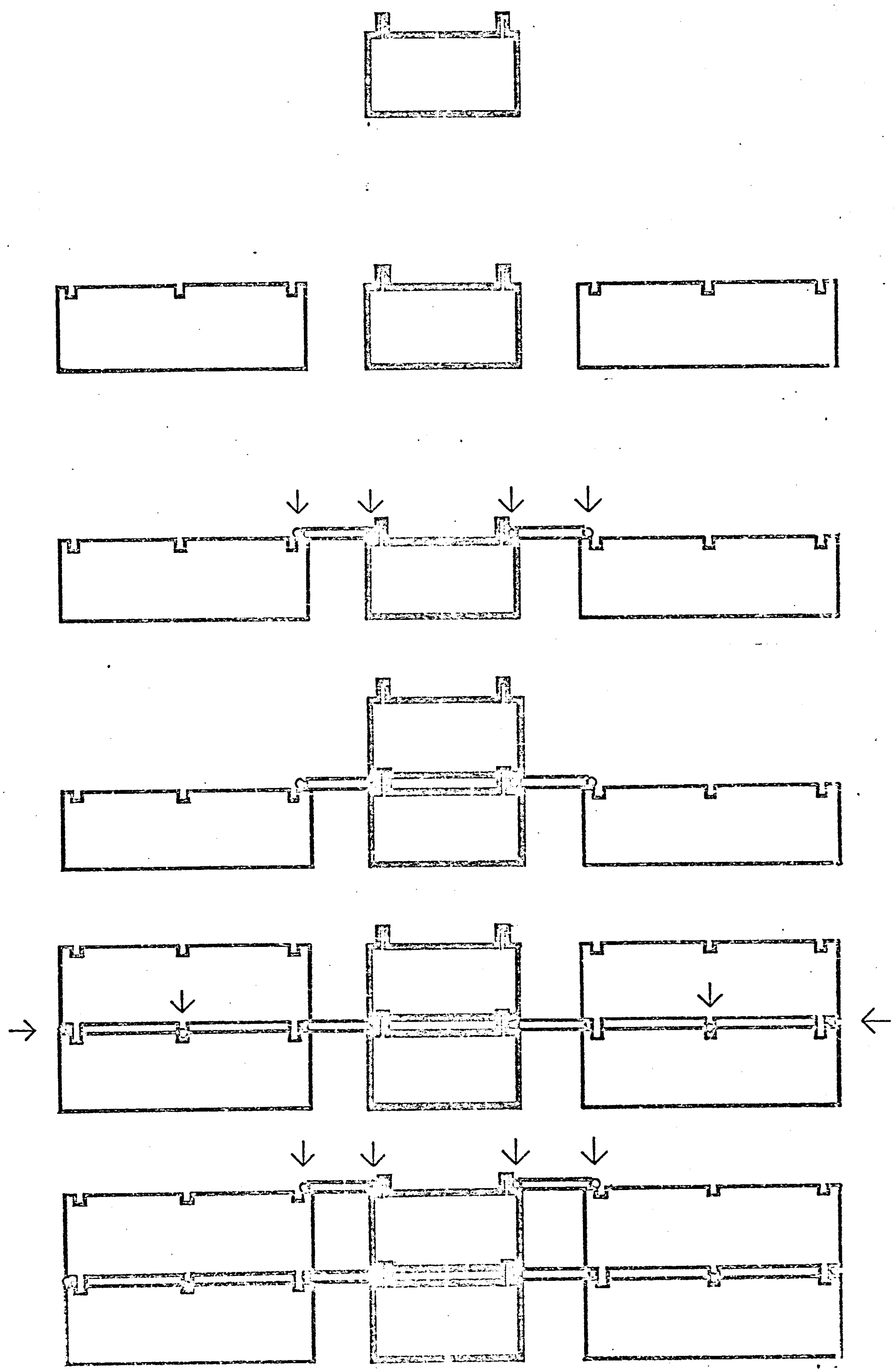
WELDING DIAGRAM A



NO SCALE

WELDING DIAGRAM B

DWELLING MODULAR UNIT CORE DWELLING MODULAR UNIT



NO SCALE DIAGRAM: CONSTRUCTION SEQUENCE